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Economic Impact of the Mass. Biomedical Industry

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Economic Impact of the Mass. Biomedical Industry

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Economic Impact of the Mass. Biomedical Industry

Abstract

Massachusetts Biomedical Initiatives (MBI) is a biomedical incubator. We assessed the economic impact of the Central Massachusetts and Boston-Worcester biomedical corridors and developed a 5-year forecast. Since 2004, the economic impact of the Central Massachusetts Biomedical industry grew 136% and today has a direct economic impact of $2.2 billion. The economic impact is expected to grow about 182% by 2012. The Boston-Worcester corridor currently has a direct economic impact of $8.8 billion.

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- Martha Farmer (Chair, Biomedical Section, NSTC
- Glen Comiso (Director of Life Sciences at Mass Technology Collaborative)

Economic Impact of the Mass. Biomedical Industry

Executive Summary

"Economic Impact of the Massachusetts Biomedical Industry" is an in depth study of the biomedical industry has done for Kevin O'Sullivan of Massachusetts Biomedical Initiatives (MBI). MBI is a biomedical incubator located in Worcester, Massachusetts. It rents space, provides equipment, and offers services to startup biomedical companies as well as established companies wishing to start up a new division. It is MBI's mission to help these companies develop to a level where they can safely enter the market without a high risk of failure. By doing this, they hope to increase the number of jobs and economic contribution within the Massachusetts biomedical industry and consequently help foster its growth and development.

Massachusetts is one of the largest and most successful biomedical clusters in the world. Arguably, Massachusetts is second only to California and has been growing rapidly since its birth with Boston as its main hub. Other than Boston, Central Massachusetts has been one of the largest and fastest growing clusters in Massachusetts. The number of biomedical companies and employees in Central Massachusetts is getting close to the numbers in Boston, and is continuing to grow. Despite the success of these biomedical clusters and the Massachusetts biomedical industry as a whole, there are obstacles that threaten their continued growth. Many of these obstacles stem from the problems that the United States biomedical industry is currently facing. The United States has been the largest and strongest biomedical industry in the world but like Massachusetts, certain obstacles are threatening its continued growth and ranking within the global industry. By transference, Massachusetts and its clusters are feeling the effects of these obstacles as well as others unique to its own industry.

This project has several of goals that address the above-mentioned issues. Its main goal was to determine the economic impact of the Central Massachusetts biomedical industry. Our sponsor, Kevin O'Sullivan, established this as the central goal. From there we determined the economic impact of what we refer to as the Boston to Worcester Corridor and made comparisons between the clusters in which the corridor is made up of. The next goal was to benchmark the United States biomedical industry and finally, to forecast these industries based on their specific metrics. With these goals accomplished, we were able to determine the status of these industries, how well they will do in the future in face of their impeding obstacles, and what can be done to overcome or prevent these obstacles from deterring the Central Massachusetts and Massachusetts biomedical industry's growth.

Kevin O'Sullivan and MBI plan to use this information as a tool to help foster the growth and development of the Massachusetts biomedical industry. They will present our findings to government officials and organizations, the media, colleges and universities, and organizations such as the Massachusetts Biotechnology Council (MBC) in hopes that it will inspire them to invest more in the industry. Also by doing this, they hope to attract more biomedical companies to Massachusetts and inspire students to do their studies in related fields and eventually join the industry. With increased amounts of funding, companies, jobs, and labor, the Massachusetts biomedical industry will hopefully be able to overcome many of its obstacles and grow to a level that can effectively compete with the largest biomedical industries in the world.

To determine the economic impact of the Central Massachusetts biomedical industry we first had to define the area it occupies in Massachusetts. Part of this study was done before in 2004 by another MQP team here at WPI. They had defined Central Massachusetts as Worcester County. In order to keep the data consistent and to make comparisons, we used the same

definition. Using Worcester County as a basis, we made a list of the companies using sources such as the Mass High Tech Journal, MBC, and MacRae's Bluebook. We contacted these companies to find the number of employees and what the 2004 team called their FTE costs. FTE costs are the costs associated with one full time employee (e.g. salary, benefits, overhead, etc.). To find the economic impact of Worcester County we took the average FTE cost and multiplied it by the total number of employees in the region. This is once again based on the 2004 methodology.

Based on the definition we received from Kevin O'Sullivan, we defined the Boston – Worcester Corridor as Boston, Cambridge, Greater Boston, Worcester County, and other areas between route 2, 9, and 90. Using the same methodology as before, we found the economic impact of these different regions and added them together to get the economic impact of the corridor. We then did regional comparisons to determine the areas with the highest number of companies and employees in the biomedical industry. We also compared their economic impacts. We did this to determine the makeup of the Massachusetts biomedical industry. It was not done with the intent of showing that these regions are in competition with each other. We actually promote unity amongst the regions as opposed to creating competition.

To benchmark the United States biomedical industry, we organized our data using Porter's Competitive advantages. This was done in order to effectively see the strengths and weaknesses of the different industries. We compared the United States with Europe and the Asia Pacific industries. We focused only on China and India for the Asia Pacific industry because those are the largest and fastest growing industries in that region. A lot of the information came from a report done by Ernst & Young which is a trusted source for market and industry data. The rest of the data came from individual case studies on the different regions.

To forecast the Central Massachusetts biomedical industry, we used a simple linear equation along with compounding. We found the average growth rate for the number of companies, employees, and economic impact, and extended it to five years using a compounding equation. We did the same for the Massachusetts industry. Knowing that this process is highly unreliable and produces inaccurate projections, we incorporated qualitative data and adjusted the growth rates based on it. The qualitative data came from case studies and expert opinions which we obtained through interviews. We also did a SWOT analysis of the individual industries to help determine their actual projected growth.

Due to a lack of information, we did not forecast the United States biomedical industry in the same manner. We used all qualitative data as opposed to quantitative in order to forecast the United States industry. We did however use the SWOT analysis in the same manner as before. We did a SWOT analysis for the United States, Europe, and the Asia Pacific region to help determine the future of the United States biomedical industry.

The Central Massachusetts biomedical industry has a direct economic impact of $2.2 billion and has grown 136 percent since 2004. We expect it to grow to $6.1 billion by 2012, which is a 182 percent increase. It has a total of 162 companies and 16,441 employees and is expected to grow to 270 companies and 47,743 employees in 2012. That is a 67 percent and 159 percent increase in growth respectively. Massachusetts has approximately 1,150 biomedical companies and 102,586 employees. We could not accurately predict the number of companies in Massachusetts for 2012 because the original growth rate was negative. We do however believe that the number will increase substantially. The number of employees will increase to about 210,446 in 2012, which is a growth of 105 percent.

The United States biomedical industry continues to be the largest and strongest in the world. Based on Porter's Competitive Advantages and the SWOT analysis we did their dominant presence in the global industry may not continue. With several governmental policies hindering growth in the United States biomedical industry and creating rapid growth in both China and India; it would not be surprising to see transference in power in the near future. Due to China's new governmental policies in funding, patent laws, drug development, trade, and tax incentives; it has seen substantial growth and if fact has the highest growth rate in the biomedical industry. The United States policies in these areas have done just the opposite and if they are not dealt with in the near future, there is a possibility of China becoming the largest biomedical industry.

As mentioned before, the majority of the problems Massachusetts and Central Massachusetts are facing today stem for the problems of the United States biomedical industry. In order to create more growth and maintain its dominance within the global industry, the United States needs to change several of its policies. It needs to increase its funding through programs such as NIH grants. It needs to create more appealing tax and trade incentives. It needs to increase funding to education especially for K-12 science education. Patent laws need to become more lenient in order to encourage the development of new drugs and products. Also, the government needs to take a more hands off stance on regulating drug and biomedical device prices.

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Economic Impact of the Mass. Biomedical Industry

1.0 – Introduction

Massachusetts Biomedical Initiatives (MBI) is a biomedical incubator whose goal is to help the central Massachusetts life science industry to grow and prosper by creating a collaboration of academia, entrepreneurs and venture capitalists. It achieves this goal by encouraging the commercialization of biomedical research in order to develop new biotechnology, medical devices, and pharmaceutical companies. MBI leases space and research equipment to entrepreneurs and large biomedical companies who wish to expand. These companies use MBI's facilities to start their operations and become established within the market. When they achieve this goal, they move on from MBI and set up their own facilities. MBI gives these companies the space, equipment, and services they need so that they can prosper in the market, which in turn helps stimulate the biomedical industry and attract new business. The companies in return pay fees on top of the rent for leasing the space. They pay a gross yearly fee, common area usage, services/maintenance, utilities, and a one percent equity agreement.

There are two main objectives this project will achieve. The first objective is to determine the economic impact of the Central Massachusetts and Boston – Worcester biomedical corridor. The second objective is to forecast the Central Massachusetts biomedical industry five years from now. There are several additional goals this project will achieve based on the two main objectives. It will determine the economic impact of other regions in Massachusetts including the Boston area and the North Shore, compare these regions to determine the percentage breakdown

of the Massachusetts biomedical industry, and then follow the same process to examine the industry on a statewide, national, and global level.

MBI's primary objective with this project is to evaluate the biomedical industry on a regional, national and global scale. MBI plans to achieve several objectives with this information. Firstly, they will use it as a tool for themselves by taking advantage of early warning signs for both good and bad changes in the biomedical industry. MBI will analyze the quantitative and qualitative trends showing where the Massachusetts biomedical industry is going. MBI, along with other institutions both governmental and private, will then make plans to either find ways of driving the industry forward or to take advantage of its growing progress. Secondly, they will provide the media with the evaluations in order to educate the public, industry, government, and educational institutions in hope that it will help build momentum and support for the industry. They also plan to use this information to show organizations such as the Massachusetts Biotech Council (MBC) and Massachusetts Medical Device Industry Council (MassMedic) whose goal is to support the biomedical industry and to ensure that the industry worthwhile to invest. Thirdly, if the research shows that the biomedical industry of Massachusetts is growing, MBI will use that research to convince organizations such as these as well as governmental agencies that it will be profitable for them and the state of Massachusetts to invest in the industry. Last but not least, some additional goals MBI wishes to achieve are to update their own biomedical state of the industry report, to evaluate the state of the industry in Massachusetts within a global environment, and to evaluate the trends of college consortiums.

In order to provide MBI with this information, benchmarking and forecasting methods must be used. Using market analysis reports, case studies, and other relevant resources, our team can benchmark the biomedical and life science industry on a regional (Worcester to Boston

"Corridor"), statewide, national, and global level for the year 2007. The research will be both qualitative (e.g., the emergence of life science facilities within the Colleges of Worcester Consortium [COWC]) and quantitative (e.g., statistics regarding the number of life science businesses that have emerged in the past five years) in nature. Using forecasting techniques, we will be able to make predictions about the direction this industry will be going five years from now. Important topics of research such as college consortiums, government policies, market analysis, and industry funding will be included to provide MBI with the above-mentioned information. The team will also evaluate other information such as the operations and policies practiced by biomedical industries in other countries, which could be applicable to the Massachusetts biomedical industry. It will also give basic information on the industry starting on a regional level and working its way up to the global industry.

2.0 – Background

The purpose of our project was to analyze the biomedical industry on different geographic levels by developing and utilizing a benchmarking system. Through the use of our benchmarks, we were able to evaluate the state of the Central Massachusetts biomedical industry and the economic impact it has on the state, determine the standing of the Massachusetts biomedical industry compared to other top biomedical states, determine America's status in the world's biomedical industry, and forecast the state of the industry on these three levels within the next five years. The following chapter will outline the importance of this study and how MBI and other biomedical incubators play a vital role in supporting the biomedical industry.

2.1 - Incubator Industry

The business incubator industry has been around since 1959 and has become an organized and necessary tool for startup companies. The National Business Incubation Association (NBIA), which was founded in 1985, defines business incubation as "a business support process that accelerates the successful development of start-up and fledgling companies by providing entrepreneurs with an array of targeted resources and services" (NBIA). Simply put, a business incubator provides the technology and resources necessary to start a company. Common resources that an incubator may make available to its entrepreneurs are materials and equipment. In the case of a biomedical incubator, this could include emergency chemical washes, lab space, refrigeration units or chemical exhaust hoods (NBIA).

Business incubators are responsible for starting a growth trend among the areas of study they house. The companies, which ideally run independently of the incubator, have an

interesting effect on local life including job production and a local interest in different fields of study. For example, MBI has joined the industry by providing biomedical incubation facilities which greatly increase the appeal of Worcester as a location to incubate or start a new life sciences related company. Additionally, the increase in jobs can help stimulate the local economy in the simplest way, since so much work needs to be done in such small facilities.

Another positive effect incubation can have on local and regional economies are government subsidies, which are provided by the government to continue stimulating local economies. NBIA reports that for every $1 provided in government subsidies to an incubator, $30 of tax revenue is produced. Additionally, studies have shown that 84 percent of incubator graduates remain in their community and stimulate the economy even further (NBIA). MBI currently hosts startup companies in three different Worcester locations. This gives a lot of exposure to the community of their existence as well as the potential for more companies to start and stay in the Worcester area.

2.2 - Massachusetts Biomedical Initiatives

MBI centered in the public's eyes in 1985 when its Worcester Board of Trustees decided to develop and implement a plan to create public/private partnerships in the community for boosting economic and life science development in Worcester. Through the use of the partnerships, MBI has succeeded in creating and maintaining its three incubator facilities in Worcester to help create "unique life sciences commercialization centers" (MBI).

MBI's mission is to "commercialize science". Their only purpose to facilitate the development and advancement of life science and biomedical device companies in the region is

to create jobs and facilitate economic development. Their ultimate goal is to fully develop Massachusetts' biomedical industry by providing fully equipped and maintained facilities for its tenants for flat rental prices (MBI). Our goal was to discuss the different regions of development for biomedical incubators and to see how MBI can benefit from the information gathered to make their company more appealing and a better player in the incubator industry.

2.3 – Global Biomedical Industry

Between the years 2005 and 2006 the global biotechnology industry has grown 14 percent in revenues, there was a 33 percent increase in R&D expenses, a 35 percent increase in net losses, a 10 percent increase in the number of employees and a 0.3 percent increase in the number of public and private companies. (Ernst & Young, pg.8) It is safe to say that the global biotechnology industry is continuing to grow at a rapid pace however; it would be a mistake to overlook the growing problems that have hindered the industry's growth. It is without a doubt that governmental, cross-border, cultural, and globalization issues have negatively affected the growth of the biotechnology industry. In this expanding industry and in the midst of these growing issues, America, Europe, and the Asia-Pacific region have become the largest players in the continuing effort to promote continued growth in the biomedical industry. Continuing strides made by these regions of the world, in achieving competitive advantage, is what has created this industries continuing success and will continue to do so in the future.

There are several factors, which both small and large companies in America, Europe, the Asia-Pacific region, as well as other countries have supported, that have contributed to the level of success the global biotechnology industry has recently experienced. The contribution levels of

each region will be discussed in further detail later on in this section. Large companies for the most part have contributed the most to the success of the global biotechnology industry but that is not to say that small startup companies have not largely supported its growth. In 2006, public and private equity investors increased total capital by 42 percent and venture capital reached an all time record of $5.4 billion. Venture capital grew by 38 percent in the U.S. and 47 percent in Europe. Large pharmaceutical companies contributed to the rest of the growth in capital. What is interesting to notice is that even the large pharmaceutical companies are restructuring their departments to be more flexible and innovative just as the small biotech companies are. (Ernst & Young, pgs.7-8)

One factor that greatly contributed to the global biotechnology industry's growth last year was the increased level of deals, alliances, partnerships, and mergers and acquisitions occurring throughout the world. Many happened within individual countries or regions such as Europe. Although benefits and growth are directly seen within the individual country or region, their achievements add on to the overall success of the global industry. Deals, merges, alliances, and partnerships are particular areas create what are known as pipelines and business clusters. These are a group of businesses that work together to gain financial support and success by sharing products, information, and equity to either create a particular product or to simply create all around growth and advancement. This trend in companies making deals is expected to increase within the next two years, which will create an even stronger global biotechnology industry. 52 percent of the companies who plan to market new products said that they will do it with the help of alliance partners and 99 percent of American biotech companies and 87 percent European companies are planning to make deals within the next two years. The majority of the companies

in this study said assistance in sales and marketing was their primary reason for entering alliances and access to capital as a close second. (Ernst & Young, pgs.9-10)

A study by Ernst and Young including over 400 companies showed that 66 percent of American companies and 76 percent of European companies said that they are planning to expand global operations (Ernst & Young). Deals made between companies in different countries or regions result in another factor that has helped create growth in the global industry. The sharing of information, products, equity, etc. through the creation of deals, alliances, mergers, and partnerships has created a level of globalization within the biotechnology industry. Although globalization is typically seen as a bad thing and has produced some negative effects for the biotechnology industry, it has benefited the growth of many countries' industries. By sharing things such as information and products and giving each other financial support through funding, biotech companies have been able to make great strides in creating new and innovative drugs as well as new strategies and procedures to cut costs and create more efficient ways of production. Globally, there has been a stronger focus on R&D and creating new products. The sharing of information and resources is essential in making a successful R&D and service oriented global biotech industry and the effects of globalization have assisted in this endeavor (Ernst & Young).

Globalization has also produced some negative effects for the biotechnology industry. There are the common problems of the exploitation of workers, taking business out of countries, the different governmental policies and regulations, etc. Besides the typical list of problems associated with globalization, some others are more specific to the biotechnology industry. One problem it has created is cross-border agreements that are currently being argued over. Topics such as tax incentives and restrictions have been large debates, especially in Europe, in the past

few years and continue to be so. (Ernst & Young, pg.66) Another problem is that small companies have trouble in gaining competitive advantage. With mergers and alliances becoming more and more common, companies are focusing more on cooperating with each other making a more unified biotech industry, which makes it harder for small companies to gain competitive advantage and succeed in the market. It is in the opinion of Michael Porter that mergers and alliances for the sake of globalization "undermine the creation of competitive advantage" and that "Real national competitiveness requires governments to disallow mergers, acquisitions, and alliances that involve industry leaders." (Porter, pg.19)

Another factor that has contributed to the growth of the global biotechnology industry is the growing industries in China and India. These countries have been rapidly expanding in the last decade and have even been predicted to become the leaders in the biotech market. Factors such as large increases in a knowledgeable workforce, product patents, a push for a more R&D and service oriented industry, as well as several other factors, have created not just created growth in the biotech industry in China and India but the world as a whole as well. These factors have also been consistent issues for the biotechnology industry in the sense that it has been lacking a knowledgeable workforce, patent rights, etc. in past years. This topic will be further discussed in the following sections.

As has been discussed throughout this section, there are some problems that the global biotechnology industry has been facing which has hindered its growth to a certain degree. One of the largest problems the industry faces is the "fourth hurdle" which health and safety agencies in many countries have been enforcing. The 'fourth hurdle" is the evaluation of the cost-effectiveness of new products (Ernst & Young). Lately, medical products, mainly drugs, have become too expensive for the common people to buy. Agencies such as the National Institute for

Health and Clinical Excellence in the U.K., as a result have been making price limits for the drugs manufactured by both large and small pharmaceutical companies. (Ernst & Young, pgs.2-3)

According to the Beyond Borders Global Biotechnology Report 2007 created by Ernst and Young, even though this issue is "often characterized as a debate about the price of drugs and the cost of health care, the core issue is really a broader one – innovation, and our willingness to pay for it."(Ernst & Young) While government agencies are concerned about the price of the drugs being sold to the public, companies argue that they cannot continue operations without making up for the large costs of producing those drugs. This issue has been a growing concern for companies, the global industry, and the governments of several countries and even though governments encourage innovation and the production of new drugs, they are not willing to pay high costs for them. (Ernst & Young, pg.4) An increase in elderly people has made this issue even worse because drugs and health care increase with the age of the population, which causes drug prices to go up. (Ernst & Young, pg.3)

The global biomedical industry has been growing steadily since its existence and has achieved a higher level of growth this year, than any other year in history except for 2002. This is not to say however, that it does not currently face problems that have hurt its growth. America, Europe and the Asia-Pacific region are the three main regions have contributed to this growth and have been facing these problems and each one is constantly looking to gain and maintain competitive advantage. The following sections are the descriptions of selected country and regions, with focus on their biotechnology industries and their areas of competitive advantages in the world market.

2.3.1 – Porter's Competitive Advantages

The following sections on the global biomedical industry are divided into parts based on what Michael Porter considers to be a nation's competitive advantages. This strategy was used to more clearly show the impact and advantages the industry has in each country discussed. There are four different attributes of national competitive advantage. There are the factor conditions, demand conditions, related and supporting industries, and firm strategy, structure, and rivalry. (Porter, p.78)

Factor conditions relates to "The nation's position in factors of production, such as skilled labor or infrastructure, necessary to compete in a given industry." Porter states, "According to standard economic theory, factors of production – labor, land, natural resources, capital, and infrastructure – will determine the flow of trade."(Porter, p.79) With the biomedical industry, resources such as an educated, skilled labor force, metals, technology, etc. would be considered beneficial factor conditions.

Demand conditions relates to the amount of demand present within the companies home country. Porter believes that "Nations gain competitive advantage in industries where the home demand gives their companies a clearer or earlier picture of emerging buyer needs, and where demanding buyers' pressure companies to innovate faster and achieve more sophisticated competitive advantages than their foreign rivals."(Porter, p.82) High age populations would be a large factor in the level of demand in a particular country for the biomedical industry.

Having related and supporting industries gives companies access to pertinent resources and provides them with new technologies and other forms of innovation (Porter). The presence

of high tech zones and business incubators would be considered competitive advantages of a country for the biomedical industry.

The firm's strategy, structure, and rivalry pertain largely to the countries culture and government. "National circumstances and context create strong tendencies in how companies are created, organized, and managed, as well as what the nature of domestic rivalry will be"(Porter, p.83). To compete on a national level, government policies, laws, and funding need to be strong and favorable towards the development of a prominent biomedical industry. This includes topics such as patent laws, drug development policies, trade laws, funding, etc. Beyond that, Porter states that the government has many roles and obligations in the development of creating competitive advantages. They need to "focus on specialized factor creation" (e.g. education & health care), "enforce strict product, safety, and environmental standards", "sharply limit direct cooperation among industry rivals", "avoid intervening in factor and currency markets", "promote goals that lead to sustained investment", "Deregulate competition", "enforce strong domestic antitrust policies", and "reject managed trade"(Porter, pp.87-89).

2.3.2 - Regional Profiles

2.3.2.1 - Asia-Pacific

The biomedical industry in the Asia-Pacific region has been rapidly expanding over the past decade or so. Last year its revenues increased by 10 percent, its R&D expenses went up by 28%, and the number of companies has increased by 4 percent. (Ernst & Young, pg.69) China and Indian are arguably the two main contributing factors to the region's growing success. Ever since their initiation into the World Trade Organization (WTO), China and Indian have made great strides to compete globally and become attractive areas to foreign investors (Liu &

Lundin). Within the past decade, certain fields of the region's biomedical industry have exceeded many of the top foreign countries and have been predicted to become one of the strongest and most prosperous in the coming ages. These predictions are predominantly based on their current growth rate within the market. For the past few years, China and India, China being stronger, have had the highest biomedical industry growth rate in the world (Ernst & Young).

Even though their biomedical industry is rapidly growing, it is still low in market share in the global market. The market shares of their biomedical products are low in the global market and their expenditures R&D, which is arguably an essential part of the biomedical industry, are also comparatively low. Despite the Asia-Pacific region's currently low market share in the global biotechnology industry, their rapid growth in the industry has obtained great attention and demonstrates their potential of becoming a dominating player in the global biomedical market.

China and India have shared several of the same attributes of success as well as growth trends in their biotechnology industries. Both industries started of as mainly manufacturing based due to the ease of creating cheap knock of drugs, created by the lack of intellectual property rights. Today they are both restructuring their industries to be more R&D and service-oriented and are seeing a lot of success because of their efforts. One of the reasons why they have seen success in this area is their hold on particular niches. China and India have a strong hold on the stem cell, gene therapy, and traditional medicinal systems mainly because of the regulations set by western governments on their own industries. They also have the advantage of cost-effectiveness and cheap labor, which has made them attractive to foreign involvement. (Ernst & Young, pgs.69-71)

2.3.2.2 – Europe

The European biotechnology industry has stayed at a steady and stable pace during the 2005-2006 year. Its revenues have gone up by 13 percent, which more than made up for its loss in 2003, its R&D expenses went up by 8 percent, the number of employees went up by 11 percent and its net loss has significantly gone down by negative 23 percent. Most of the industry's growth is contributed to large companies whom made up for approximately 80 percent of public company revenues. Europe, like the Asia-Pacific region, has a strong focus on R&D. 32 percent of public company revenues and 67 percent of private company revenues account for R&D expenditures. Much of Europe's biotechnology industry's success can be attributed to the high levels of financing, the increase in percentage of the products developed, which was at 30 percent, and the large number of deals, alliances, and mergers and acquisitions. (Ernst & Young, pgs.45-47)

2.3.2.3 – America

America currently has the largest biopharmaceutical market in the world with many of its drugs being developed due to biotechnology. It has more than 300 public biotechnology companies which employs over 130,000 people and represents $400 billion in market capitalization (Ernst & Young). It has remained the leader in the global biotechnology industry's revenues, profits, and jobs. Continuing with its current trend, the American biotechnology industry has substantially grown in the last year. Revenues grew by 13.4 percent, sales grew by 13.4 percent, R&D expenses increased by 30.2 percent, the net loss increased by 58.5 percent and employment increased by 6 percent (Ernst & Young). These numbers are accurate although deceiving. The industry's net loss was 58.5 percent, which would commonly indicate a rough

year for the industry, but this was mainly due to two large acquisitions made that year (Ernst & Young). If these acquisitions had not occurred then the industry total revenues would have increased by 20 percent, the net loss would not have been so high and most importantly, the biotechnology industry would have been profitable for the first time in 31 years (Ernst & Young). Considering this, the American biotechnology industry did considerably well last year. However, it goes without saying that the industry faced several issues and roadblocks throughout the year and is continuing to do so.

2.3.3 - Government Incentives & Involvement

2.3.3.1 – China

The Chinese government has been an integral contributor to the growth of biomedical industry and has been a supporter of it for many years now. Originally China's biomedical industry was heavily based on manufacturing and has seen a lot of success because of it. It has been predicted that the top biomedical companies of the world will have lost around 80 percent of their market due to generic competition. The majority of China's domestic products happen to be imitation/generic drugs as well as Traditional Chinese Medicine (TCM). The reason for the high production of imitation drugs is mainly contributed to the lack of sufficient ownership rights such as patents. This subject will be discussed further later on. (Liu & Lundin, pg.7)

Even though manufacturing is the backbone of their biomedical industry and has seen great success; in the past few years the government has made great strides to change the industry from manufacturing to R&D by changing what they refer to as the national innovation system as well as joining the WTO. They believe that this will improve the biomedical industry by attracting foreign investment, creating opportunities for the development of new products, and by

adding an essential part of the industry that had been lacking in the past. The national innovation system consists of providing R&D with funding through grants and subsidies, and research institutions, government incentive programs, and contributions to higher education. (Liu & Lundin, pg.4) The Chinese government is also currently carrying out its eleventh five-year plan which increases biotech funding in several areas including screening for genetic diseases, developing biotech-based drugs and vaccines that are currently relevant to the diseases in China and increasing contract research services. (Ernst & Young, pg.77)

The government has also been increasing its regulations and policies, mainly with focus on safety. In April of 2006 the government announced its recognition of the State Food and Drug Administration with the intent of preventing fraud, improving the drug approval process and prohibiting companies from using old products and selling it under different names. Also pertaining to safety, the government plans to "monitor drug companies, establish drug safety and review centers, and improve post-marketing surveillance." (Ernst & Young, pg. 77) The Chinese government has also made efforts to improve manufacturing and intellectual property rights. It imposed the Good Manufacturing Practice requirements, which is intended to improve manufacturing quality and help consolidate the domestic industry. (Ernst & Young, pg. 77)

In the past China has been know for not having strict intellectual property rights but now they have been making strides to change this through an increase in patents and other forms of protection. Ernst & Young did a study of the level of intellectual property rights by recording the amount of scientific paper citations, biotechnology patent applications, high school proficiency and the share of global biotechnology patents of several countries. The U.S., Japan, and some European countries such as the U.K. and Germany, were the top countries in scientific paper citations and the share of global biotechnology patents, which measures the growth of the

industry's current and past strengths in science and R&D. China and India however were the leaders in the high school proficiency rank and the growth in biotechnology patent applications, which measures the growth trends and investments in the future. (Ernst & Young, pg.6)

2.3.3.2 – India

The Indian government has made great efforts to help the biotechnology industry prosper. As mentioned before, the government has instituted stricter policies and regulations regarding intellectual property rights. In 2005, policymakers instituted the Indian Patent Act which allowed the patenting of pharmaceuticals for the first time. A strong push is currently being made for the institution of the National Biotechnology Development strategy which would promote innovation in smaller companies in several ways. A single National Biotechnology Regulatory Authority would provide faster and more efficient clearance of biotech products and would allow for faster foreign direct investment. Also, the government plans to support the creation of Special Economic Zones which are biotech parks. Currently there are only 5 parks in India. The parks are intended to create business cluster including companies, universities, and R&D institutes. (Ernst & Young, pg.79)

2.3.3.3 – Europe

European governments are trying to promote the biotechnology industry in three main ways two of which are funding incentives and the other tax incentives. The Seventh Framework Program for Research and Technological Development (FP7) and state aid for Young Innovative Companies (YIC) are the two recent funding incentives European countries have implemented. (Ernst & Young, pg.65) FP7 brings together European research initiatives to gain economic

growth, competitiveness and employment. (cordis.europa.eu/fp7/understand_en.html) Its primary goal is to build a knowledge based European economy by funding food, agriculture, and biotechnology research. YIC is a status a company can achieve which grants them exemption for certain taxes and social contributions. The goal of granting these exemptions is to promote R&D and decrease the amount of time it takes to get new products out to the public. Also, to encourage the growth of pipelines European governments are currently pushing for tax breaks in cross-border trading similar to that of NAFTA between America, Mexico, and Canada. Many see "the lack of corporate tax harmonization across the EU is often viewed as being detrimental to the competitiveness of European business." (Ernst & Young, pgs.65-66).

2.3.3.4 – America

Unlike China, India, and Europe, U.S. governmental policies have been problematic for its biomedical industry. Many of the governmental policies that give the Asia – Pacific and European regions their competitive advantages are almost opposite to that of America's. These policies have damage almost all areas of America's competitive advantages with specifics to education, financing, patent issuance, and indirectly internal demand.

As mentioned in the section about the global biotechnology industry, one of the largest problems the global industry is facing is the "fourth hurdle" (Ernst & Young). America has been especially affected by this need for price regulations on pharmaceutical drugs. America's age demographic is getting older and older due to advancements in the medical field which has dramatically increased the life expectancy of people (Ernst & Young). Health care is becoming increasingly expensive with these aging demographics which have created debates on the regulation of drug prices. If governments impose strict pricing limits then the companies will not

be able to produce the drug. If the companies set too high of a price, the decreasing middle class and lower class will not be able to afford the drugs which will give the same result (Ernst & Young). Congress has worked towards alleviating this dilemma with acts such as the Medicare Modernization Act's "non-interference" clause which prohibits the government from directly negotiating with manufacturers on prices. The Secretary of the Department of Health and Human Services would however have this right (Ernst & Young).

It is becoming increasingly harder for biomedical companies to obtain patents and develop new products due to the laws and regulations set in place by the U.S. government. A lot of the problems stem from the strict policies of the FDA and the increasing concerns of ideas for products and research being stolen. Some other problems involve trade and financing. NIH funding, which has been one of the largest sources of federal funding, has gone down in the biomedical industry. Also, America's strict trade and foreign entry policies has caused venture capital to decrease and has put us at a disadvantage to Europe's strong pipeline and networking system, which has provided it with related and supporting industries and increased product development.

2.3.4 - Research Institutes & Incubators

2.3.4.1 – China

The Chinese government has been creating biomedical parks and a high-tech zone since the 1980's, providing incubating facilities for biomedical companies. These high-tech zones provide several benefits and have helped prosper the push for a more R&D oriented industry. Firms in these high-tech zones benefit from tax incentives, "a new governance model", and an increase in business clusters. The governance model focuses on "a smaller government with

more services" and helps firms "reduce their transaction costs and more efficiently facilitate their activities." The business clusters formed within these zones help provide a stronger networking system, which allows companies to benefit from each other's research and successful attributes, as well as increasing prosperity within the industry as a whole. (Liu & Lundin, pg. 76)

Approximately ninety percent of China's high-tech firms and incubators are now located in these high-tech zones and by the year 2005 over 490 incubators had been created across the country. Although the majority of these firms and incubators are information technology oriented, the biomedical firms have a large presence and benefit greatly from these other companies. In the past these incubators were funded and managed mostly by governmental agencies. Recently, the government has been encouraging joint ventures, large corporations, and private investors to invest in these incubators and as a result, over half of them are currently funded, established, and owned by non-governmental investors. (Liu & Lundin, pg. 76)

These actions have greatly helped the government's goal in shifting to a more R&D oriented biomedical industry. The incubators provide the facilities, funding, support, and opportunities biomedical firms need to do R&D activities. The non-governmental and foreign investments in these incubators have and will continue to produce a growth within the industry that because of limited resources; the Chinese government is not capable of. (Liu & Lundin, pg. 76)

2.3.5.2 – America

America has the largest and strongest biomedical clusters in the world and is greatly supported by its incubators and research institutes (MBC). Its biomedical incubators are used as

a model for the rest of the world and are considered to be the best and most efficient. They have allowed startup companies to enter the industry with great success, which consequently has increased the number of companies, employees, and economic impact of the U.S. biomedical industry. On top of that, America has some of the most prestigious colleges and universities in the world which have provided a knowledgeable labor force to the industry as well as additional R&D and biomedical facilities.

2.3.5 - Education

2.3.5.1 - China & India

Both the Chinese and Indian governments have been supporting their academic facilities for many of the same reasons, their main goal being to promote the sciences so that there will be a more knowledgeable and experience workforce to enter the biomedical industry. The educational trends are so similar between the two countries that this section will solely focus on China. The Chinese government has contributed a lot of funding and support to its country's universities and hospitals. Both the government and Chinese citizens realize that the biomedical industry is the most prominent and prosperous in the country. Two important occurrences stem from this realization, the first being socially related and the second governmentally. The Chinese people realize that being educated in the biomedical field is the fastest and best way to achieve success financially and career wise. For this reason, there is a large population of biomedical students and graduates ready to enter and contribute to the industry. (Liu & Lundin, pgs.53-55) There has also been a large influx of foreign-educated Chinese who have returned to work in biomedical industry in China. (Ernst & Young, pg. 77) The government wants to encourage and support this phenomenon in order to help increase the level of research and development in the

industry. They do this by giving funding directly to the universities as well as encourage and fund the development of incubators. (Liu & Lundin, pg.55)

There are two main reasons why universities are such an integral part of the biomedical industries. The first reason is that they contribute to the networking system previously discussed. The second reason is that it produces a large educated workforce for the industry. This is very appealing to foreign investors. Not only does China have a large workforce, it has a large educated workforce that can be hired for cheaper wages and salaries. Having this type of workforce not only helps the biomedical industry as a whole, it helps the government make the transition from a predominantly manufacturing industry to a knowledge based R&D one.

2.3.5.2 – America

According to a surveys done by Ernst & Young as well as PricewaterhouseCoopers, many biomedical companies feel that education for science in the K-12 grades has been severely lacking. According to Ernst & Young, America is 20th in the world for high school science proficiency. Finland and Japan tied for number one and Korea came in at number two. In general, America's high school science proficiency is severely lacking compared to the European and Asia – Pacific regions.

2.3.6 - Outsourcing and Globalization

2.3.6.1 – China

Even though outsourcing and globalization has many disadvantages and has negatively affected the economies of some countries, it has greatly benefited China and its biomedical

industry. Foreign investment has become an important necessity for the industry and is one of the main reasons for its rapid growth. It mainly began with China's induction into the World Trade Organization and was further promoted by the government and environmental conditions such as an educated workforce.

As mentioned before, the industry was originally based on the intense manufacturing of biomedical products. There were little to no patents granted to organizations so imitation and generic drugs became a popular product to produce. Since manufacturing became such a big part of the industry, the government feared that by giving patents industry growth would falter. When the government decided to join the WTO and increase R&D in the industry patent laws were changed and became more frequent. This allowed foreign investors to comfortably establish themselves in China without any fear of losing the products they create to other competition. (Liu & Lundin, pgs. 4-5)

Two other reasons foreign investors became interested in China are the large, cheap, and educated workforce it provides (previously discussed in the education section) and its openness to controversial scientific research. Many countries in the world do not approve of research done on stem cells and gene therapy and therefore make it illegal to do so. China does not have any restrictions in these areas of research. Many large biomedical companies will establish themselves in China solely for this reason. (Liu and Lundin, pg.23)

2.3.6.2 – India

According to Naleish A. Bhatt, author of 2007 article Dynamics of India's Life Sciences Outsourcing Industry, the World Trade Organization's implementation of the General

Agreement on Tariffs and Trade/Agreement on Trade-Related Aspects of Intellectual Property (GATT/TRIPS) in India, opened up its biotechnology and pharmaceutical industries to the effects of outsourcing. (Bhatt, pg.65) He believes that this event changed these industries in three different ways. An increased level of comfort among global pharmaceutical and biotechnology companies encouraged doing work in India as well as with Indian companies. Several global investors sought to invest in the different fields of their biomedical industry and Indian corporate executives shared this eagerness to cooperate with global investors. After the implementation of this agreement India's biomedical industry became more diverse and grew to become one of the leading biomedical markets. (Bhatt, pg.65)

The Indian biomedical industry's increased exposure to outsourcing and its resulting metamorphosis and growth greatly resembles what occurred in China around the same time. Both countries biomedical industries were originally based on the heavy manufacturing of generic drugs and cheap medical devices. The lack of property rights in India prospered this manufacturing trend and at the same time discouraged foreign companies to invest in their industry. When the WTO implemented the GAFT/TRIPS agreement, both of the country's biomedical industries became more R&D and service oriented. Their market shares in the industry greatly increased as well due to increased outsourcing and foreign investment. India is the second most sought after country by global investors and China is currently the first. (Bhatt, pg. 67)

Bhatt believes that one of the main reasons for the increased level of outsourcing is a higher comfort level of global investors and that several of factors are responsible for this. An important contributing factor to the increased level of comfort is "India's liberal and attractive investment policies, coupled with highly liquid financial markets." Instead of foreign companies

simply investing in an Indian corporation, they invest directly into specific projects. Some other key factors that Bhatt listed in his article are the presence of scientists with experience in global firms, proof that Indian companies can create value in a cost effective manner, and large opportunities in healthcare created by the Indian population. Once again, this is comparable to what happened in China. In general, an educated workforce, cheaper operational costs and opportunities for growth as a result of their current populations encouraged increased foreign investment. (Bhatt, pg. 67)

2.3.6.3 – Europe

Several of companies in Europe have established pipelines not just among themselves, but with the U.S. and Asia as well. Keeping up with the trends of globalization, European companies have made several mergers and acquisitions as well as alliances with predominantly countries within Europe and with America. In 2006 mergers and acquisitions between European countries increased by 59 percent. It increased 36 percent with America and 5 percent with Asia. Many of the companies preferred to make deals in Europe to acquire American companies and create mergers and alliances between pharmaceutical and biotech companies. Although Europe's level of cross national deals is low compared to that of America's and Asia's, the European biotechnology industry has been able to sufficiently keep up with the increasingly necessary trends of globalization. (Ernst & Young, pgs.57-60)

2.4 – Regional Industry

2.4.1 – Colleges of Worcester Consortium (COWC)

The Colleges of Worcester Consortium (COWC) exists to develop and manage collaborative services that enhance the educational missions and improve the operational effectiveness of its member institutions. The Consortium is a not-for-profit organization which was founded in 1968 by the presidents of the colleges and universities. These college leaders recognized it was desirable to jointly address common issues of importance to their institutions, to higher education in the region, and to their communities. COWC currently has thirteen governing-member colleges and thirteen associate members located in Central Massachusetts of which membership is voluntary. The thirteen colleges and universities which comprise the Colleges of Worcester Consortium, Inc. include nine Worcester-based institutions and four institutions in the greater Worcester area. A list of all colleges within COWC is in Table A. This unique partnership offers students a number of benefits, including cross-registration among the colleges, dual-degree programs, cooperating library privileges and a variety of collaborative career services. Its mission is to work cooperatively to further the missions of the member institutions individually and to advance higher education regionally. The Consortium has three major areas of focus: to provide organizational effectiveness and shared services among its college and university members; to provide access to higher education opportunities for low-income students and adults; and to cultivate local and regional economic development and civic engagement opportunities. (COWC 2007)

Besides supporting the education, COWC also has a strong impact on Greater Worcester and the State of Massachusetts. The Consortium helped its member institutions communicate their economic, intellectual, educational, and cultural impact on Greater Worcester and the

Commonwealth of Massachusetts with special emphasis on serving the local region and its people. Also, The Consortium enhanced the economic benefits to members through increased emphasis on programs and services that provide cost savings and efficiencies.

Recently, most colleges within the COWC have built their own life science facilities (e.g. Worcester Polytechnic Institute just opened its biotechnology centers called Gateway Park; and the College of Holy Cross is in the midst of constructing a $60 million Integrated Science Complex). Therefore, MBI wanted to look at the trend of COWC and its impact on the biomedical incubator industry within the Central Massachusetts.

Figure 1: Colleges of the Worcester Consortium

	Colleges Within COWC
1	Anna Maria College
2	Assumption College
3	Atlantic Union College
4	Becker College
5	Clark University
6	College of the Holy Cross
7	Massachusetts College of Pharmacy and Health Sciences
8	Nichols College
9	Quinsigamond Community College
10	Tufts Cummings School of Veterinary Medicine
11	University of Massachusetts Medical School
12	Worcester State College
13	Worcester Polytechnic Institute

2.5 – Benchmarking

Benchmarking will be the most important method for evaluating the current standing of the biomedical industry on a regional, national, and global scale. Benchmarking is the process of improving performance by continuously identifying, understanding, and adapting outstanding practices and processes found inside and outside the organization or from organizations anywhere in the world (American Productivity & Quality Center). The objective of benchmarking is to understand and evaluate the current position of a business or organization in relation to best practice and to identify areas and means of performance improvement. In addition, benchmarking helps organizations identify standards of performance in other organizations and to import them successfully to their own. It allows organizations to discover where they stand in relation to others. By identifying, understanding, and comparing the best practices and processes of other organizations with its own, an organization can target problem areas and develop solutions to achieve best levels of performance.

Benchmarking is often done by companies and organizations who want to improve their effectiveness and expand their businesses. Benchmarking efforts typically collect information on responsibilities, program design, operating facilities, technical know-how, brand images, levels of integration, managerial talent, and cost of financial performance. Companies and organizations benchmark for many reasons: they want to determine where they spend their time and how much value they add, or they are curious about how they stack up against others. Through the knowledge gained by benchmarking, organizations and companies redefine their roles, add more value, reduce costs, and improve performances. (Blinn 1998)

There are three methods of benchmarking that could be used in determining the economic impact of the Central Massachusetts biomedical industry: competitive, generic, and functional benchmarking.

1. Competitive benchmarking involves analyzing outside organizations that are known to be the best in their industry. Competitive benchmarking provides opportunities of learning from those who are at the leading edge. Typically this is done by reviewing trade publications and competitor literature, and by hiring individuals who are familiar with competitor processes. In competitive benchmarking, a consultant or a third party rather than the organization itself collects and analyzes the data because of its proprietary nature. (Hurwicz 1998)

2. *Generic* benchmarking investigates activities that are or can be used in most businesses. This type of benchmarking makes the broadest use of data collection. One difficulty is in understanding how processes translate across industries. Yet generic benchmarking can often drastically alter an organization's ideas about its performance capability and result in the reengineering of business processes. (Evans 1999)

3. Functional benchmarking involves the analysis of a particular function which may be common within an industry. This is typical for automated processes that utilize commercially available software. A team of potential software users will visit a business that has agreed to serve as a show case for the software. This type of benchmarking is an opportunity for breakthrough improvements by analyzing

> high-performance processes across a variety of industries and organizations. (Camp 1995)

Benchmarking is a tough process that needs a lot of commitment to succeed. Its models are used to determine how well a business unit, division, organization or corporation is performing compared with other similar organizations (Christopher E. Bogan, 2003). However, not all benchmarking projects are accurate. More than once benchmarking projects end with the "they are different from us" syndrome or competitive sensitivity prevents the free flow of information that is necessary (Value Base Management.Net).

Typically, there are a lot of steps that involve within benchmarking process. In order to generate the three benchmarking methods that we mentioned above, the following steps need to be done. First, a project team must identify the scope definition of the benchmarking project, which we already did. The next step would be determining which benchmark partners to choose, as well as determining specific benchmark values by collecting and analyzing information from surveys, interviews, industry information, direct contacts, business or trade publications, technical journals, and other sources of information. Then we will start making data collection and analysis of the discrepancies. The fourth and most important step is that a project team will present the results and discuss implications or improvement areas, and come up with the improvement plans or new procedures. (George 1992)

2.6 - Forecasting

The process by which organizations ponder and prepare for the future that involves predicting the future outcome of various business decisions is known as forecasting. Forecasting provides organizations important information on the future business as a whole, the future of an existing or proposed product, and the future of the industry in which the business operates. In order to forecast, a project team uses existing data, facts, and rely on technical and fundamental statistics to predict the direction of the economy and the industry. Accurate forecasts are used by organizations to assist them in making business decisions and give them the opportunity to grow their businesses effectively in the related industry.

Forecasting is important to our project because one of the major objectives of this project is to make a five-year prediction as to where the biomedical incubator industry is going and on where Worcester region position is in the future. There are several different methods that can be used to create a forecast. The method a forecaster chooses depends upon the experience of the forecaster, the amount of information available to the forecaster, the level of difficulty that the forecast situation presents, and the degree of accuracy or confidence needed in the forecast. The most basic method of forecasting which could be used for Massachusetts Biomedical Initiatives is the "Qualitative Forecasting Methods". Qualitative Forecasting Methods are based on educated opinions of appropriate persons. They have three different sub-methods that could be used to forecast the industry: Market research and expert judgment.

Market research is the process of systematic gathering, recording and analyzing of data about customers, competitors and the market. Market research can help the company create a business plan, launch a new product or service, fine tune existing products and services, and

expand into new markets. It can be used to determine which portion of the population will purchase the product or service, based on variables like age, gender, location and income level. Market characteristics of target market can be found out. (MacNamara n.d.) With market research, companies like MBI can learn more about current and potential customers, as well as the trend of biomedical incubator industry.

Expert judgment is an approach for soliciting informed opinions from individuals with particular expertise. This approach is used to obtain a rapid assessment of the state of knowledge about a particular aspect of climate change. It is frequently used in a panel format, aggregating opinions to cover a broad range of issues regarding a topic. Expert judgment is frequently used to produce position papers on issues requiring policy responses and is integral to most other decision-making tools. (Smith 1990)

Another method of forecasting which also may be used is the "Causal/Econometric Method". Causal forecasting methods are based on a known or perceived relationship between the factor to be forecasted and other external or internal factors. This forecasting method is based on the process of analyzing and developing the statistical models through research, existing data, and economic principle in order to make prediction for the economic in the future. Causal forecasting is concentrated on four different models: regression, economics, input-output, and simulation model. Regression model is based on mathematical equation which relates a dependent variable to one or more independent variables that are believed to influence the dependent variable. Econometric models are the system of interdependent regression equations that describe some sector of economic activity. An input-output model is used to describe the flows from one sector of the economy to another, and so predicts the inputs required to produce outputs in another sector. The advantage behind the Causal/Econometric Method is that it

provides a more accurate forecasting, but in contrast, it is often so complicated and is not simple to generate. (Sparling 2006)

3.0 – Methodology

3.1 - Determining the Economic Impact of Central Massachusetts

In order to determine the impact of the Central Massachusetts biomedical industry, we first had to define what Central Massachusetts consists of. Using maps and county data, we found the cities or towns that make up Central Massachusetts and the Worcester country. This is shown in Appendix A.

The number of life science companies in Central Massachusetts was collected using archival research on national databases, companies' websites, and available business journals. One important source that the project team used was the information published by the Massachusetts Biotechnology Council (MBC). Based on the information on October 2007, MBC has a total of 566 companies as members. 352 of them are biotechnology companies and 47 companies are nonprofit research institution (including MBI). Another important source was the Massachusetts Medical Device Industry Council (MassMedic). However, both MBC and MassMedic do not show all of the life science companies in Central Massachusetts.

The team also contacted the town clerk office in Worcester to get a list of all the companies that have been started up in the past five years. Every company is required to register with the government when they establish themselves which mean that the town clerk has a comprehensive list of the startup biomedical companies. However, this does not provide information on how many employees they have, how much revenue they generate and other financial data. This information is hard to collect due to company protectionism, so we did not go into an extensive search for it.

To determine the economic impact of the Central Massachusetts biomedical companies, we used the same method as the 2004 report. It followed the same strategy as determining the impact of WPI and extended it to a broader level. To do this we had to separate the data by companies with less than 500 employees and more than 500 employees in order to gain a more accurate average of the number of employees in Central Massachusetts. To find a more accurate number of the employees, we used the equation provided in the 2004 report. We then multiplied it by the average expenditure per full time employee to determine the economic impact.

3.1.1 – Boston – Worcester Corridor and Other Regions

On top of the Central Massachusetts biomedical industry, we analyzed the Boston – Worcester corridor, the North Shore, and another area we labeled as Northern Massachusetts. The Boston – Worcester corridor includes the Boston area which is Boston, Cambridge, and Greater Boston. Greater Boston is the surrounding area of Boston that is within the route 95 line. The North Shore is the area above Greater Boston and Northern Massachusetts lies to the west of that. These areas and their corresponding list of cities can be found in Appendix B**.**

To find the economic impact of these areas we followed the same methodology as the Central Massachusetts. We made a list of companies and the number of employees they have, found the average FTE costs, and then multiplied that by the total number of employees to get the economic impact. We then used these numbers to make regional comparisons and determine the percentage these areas take up of the Massachusetts biomedical industry. Comparisons were made using the total number of companies and employees, average FTE costs, and economic impact.

These comparisons were not made to show that one area is doing better than the other or to suggest that these regions are in competition with one another. One of the goals of this project is to promote interaction between these regions so that the entire Massachusetts biomedical industry can grow. These comparisons were done for a couple different reasons. The first one was to see if the numbers we obtained are relatively close to what has been seen in the past and what are currently expected. If they do not match then it can be assumed that these figures are not accurate. The other reason was to simply get a breakdown of where the concentrations of regional biomedical industries fall within the Massachusetts biomedical industry.

3.2 – Benchmarking the Massachusetts Biomedical Industry and Beyond

An extension to this study was benchmarking the biomedical industry on a statewide, national, and global level. Essentially, the same methods were used to benchmark on all levels and mainly consisted of market analysis data. To benchmark Massachusetts, we first found a set of metrics used in previous benchmarking studies and then compared Massachusetts to the top biomedical industries in the United States. Because these studies are done infrequently, we found the latest data that could be applied to all of the states even if some of them had more up to date analysis. The differing data must be consistent with dates and unless it is being compared to its past self, data cannot be compared at different points in time and at different levels. For this reason, we could not incorporate current Massachusetts biomedical industry data into the benchmark. Many analyst studies of state biomedical industries provided all information of the metrics so extensive data mining was not necessary.

The same method was used to benchmark the United States biomedical industry and the rest of the world. The only difference is that instead of analyzing the top biomedical states, we

analyzed the top biomedical countries. We used general global reports as well as country analysis to do this. The Ernst & Young report was our only global source we had due to a lack of studies done on this scale. Data mining techniques and the OECD was used to analyze particular countries.

3.3 - Impact of the COWC

Recently, many colleges within the Colleges of Worcester Consortium (COWC), built their own life science facilities (e.g. Worcester Polytechnic Institute (WPI) just opened a biotechnology center called Gateway Park), and have contributed greatly to the Massachusetts biomedical industry. The team contacted Mark Bilotta who is the Chief Executive Officer (CEO) of COWC. We asked Mr. Bilotta some specific questions pertaining to the size of the life science center at each college, how much was spent to build these facilities, and the specialty at each facility. In addition, we asked Mr. Bilotta to provide a list of contact information of the project managers or individuals who were responsible for development of the life science centers. We asked these managers more in depth questions regarding specific information of the science center at their school, as well as their opinion on the status of the biomedical industry in the Central Massachusetts.

In order to determine the impact of the COWC we used these resources to find out how many startup companies have come out of these colleges and universities. Using the same method we used in determining the impact of the Central Massachusetts biomedical industry, we determined the impact these schools had on the industry. We also found how many biomedical graduates the schools were graduating per year and how many patents were issued through the companies and their studies.

3.4 - Forecasting

Forecasting is the important method for making prediction on the biomedical incubator industry. In order to forecast, our project team had used a few methods including interviews with a few groups of experts within the biomedical incubator industry. For instance, two of the people we interviewed were from the Massachusetts Biotechnology Council (MBC) and Massachusetts Medical Device Industry Council (MassMedic). These interviews were mainly used to gain qualitative data. Specific questions that focused on the trends of the industry were asked. Also, the team requested for useful data including industry reports which provided both quantitative and qualitative data needed to forecast the industry. Market research methods were also used to collect data. We looked at available electronic resources such as databases, electronic reports, MBC and MassMedic websites, etc.

Benchmarking was a key tool in forecasting the biomedical industry's status in the next five years. By having current and past data, we were able to determine growth rates in several fields. We looked at key growth rates such as market capitalization, patent distribution, revenues, net loss, employment, etc. To determine these growth rates, we used past and present industry averages and then extended it to five years using a linear equation as well as compounding. The basic equation was X*(1+A)^R where X is the 2007 data, A is the average growth rate per year, and R is the number of years being forecasted (in most cases five years). Charts and graphs were an essential tool in forecasting the biomedical industry.

3.5 - Market Research

In order to benchmark the biomedical industry the team collected market research with specifics to corporate data and industry data analysis on a regional, statewide, national, and global level. Some important factors that were analyzed are total sales, total employment and employment rates, exports, land occupation, etc. The numbers for these factors were obtained from current and past market reports given by corporations, industry analysis, MBI, and past MQP reports. Some specific sources we used were government sites such as the census, biomedical councils, interviews, library databases, and more. When the team collected a sufficient amount of research, we analyzed the data and used benchmarking methods to determine the state of the industry.

3.5.1 - Analysis

The method the team used to analyze the market research is the SWOT analysis. Typically SWOT analysis is used as a strategic planning tool for a project and a business venture. In this case, the team used it as a planning tool and a means of an evaluation for the biomedical industry. The SWOT analysis involves determining the strengths, weaknesses, opportunities, and threats of internal and external conditions. Based on this, the team determined the strengths and weaknesses of the industry based on the quantitative research. These data were provided by the market analysis, corporate reports, and by interviews, articles, government involvement and regulations, population trends, etc.

Determining the opportunities and threats of the industry was part of the forecasting section of the project. The team determined where we believe the biomedical industry will be

five years from now by analyzing the opportunities and threats discovered through mainly qualitative research. That is not to say that quantitative research was not used to make these predictions.

4.0 – Analysis

This chapter contains two main sections. The first section shows the economic impact of the Central Massachusetts biomedical industry. It explains how we found the number of companies and employees as well as how we found the economic impact by using an average FTE cost. The second section benchmarks the Massachusetts biomedical industry with other states in the United States. It also benchmarks the biomedical industry of the United States with other prominent countries. We feel that these numbers are fairly close to accurate based on our research and professional studies. We found 1,133 companies in the Massachusetts biomedical industry and the PricewaterhouseCoopers estimated the number to be around 1,150 companies. Based on this our numbers and calculations should be fairly accurate.

4.1 – Economic Impact of Central Massachusetts

To find the economic impact of the Central Massachusetts biomedical industry, we had to do three steps. The first step was to compile a list of all the companies located in Central Massachusetts which was done with resources such as MBC, MassMedic, and MacRae's Blue Book. We used this list to make a database of all the pertinent company information which included whether or not it was a startup, the number of employees, and contact information. If we could find the number of employees in our data sources then we contacted the companies either by phone or email. We also contacted the companies to get their average FTE costs.

Because we could not get the number of employees for every company, an average was done and added to the total number of employees calculated in the database. The total number of employees we found in Central Massachusetts was 12,742 which came to an average of 82

employees per company. There were 45 companies without employee information. ((82*45) + 12742) came to a total of 16,441 employees in Central Massachusetts.

Every company in the Central Massachusetts database was contacted to obtain their average FTE costs. Forty-one of the 162 (25%) companies gave out this information and the FTE costs averaged out to be about $150,000. In order to be consistent with the 2004 report we took out all the companies that had an FTE cost of $175,000 or higher. The average went down to approximately $133,000 per full time employee. The number of employees times the average FTE cost gives us the economic impact of the Central Massachusetts biomedical industry, which turned out to be around $2,200,000,000.

4.1.1 – Benchmark of the Central Mass Biomedical Industry

Benchmarking the economic impact of the Central Massachusetts industry with past information allows us to see how the industry has fared within the last three years and helps us forecast its level of economic impact five years from now. In 2004 the economic impact was approximately $925,000,000 and the average FTE cost was $128,000. In 2007 it was about $2,200,000,000 and $133,000 respectively. This resulted in a growth of 136 percent for the economic impact and about four percent for the FTE Cost. The table and charts show the below mentioned changes.

	2004	2007	Difference	% Change
Average FTE Costs	$128,000	$132,580	$4,580	3.58%
Economic Impact	$925,000,000	$2,179,764,221	$1,254,764,221	135.65%

Figure 2: FTE cost in Central Mass

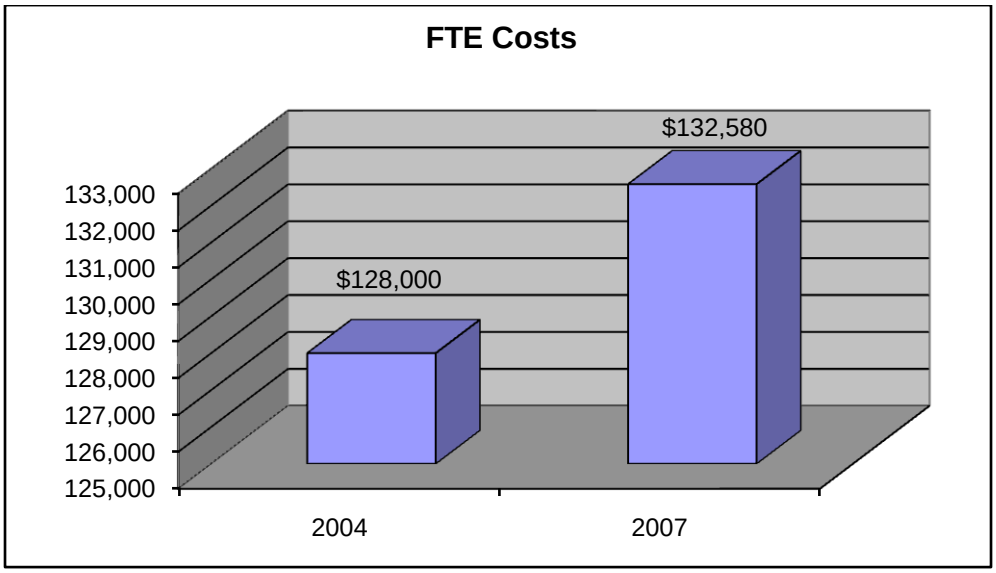
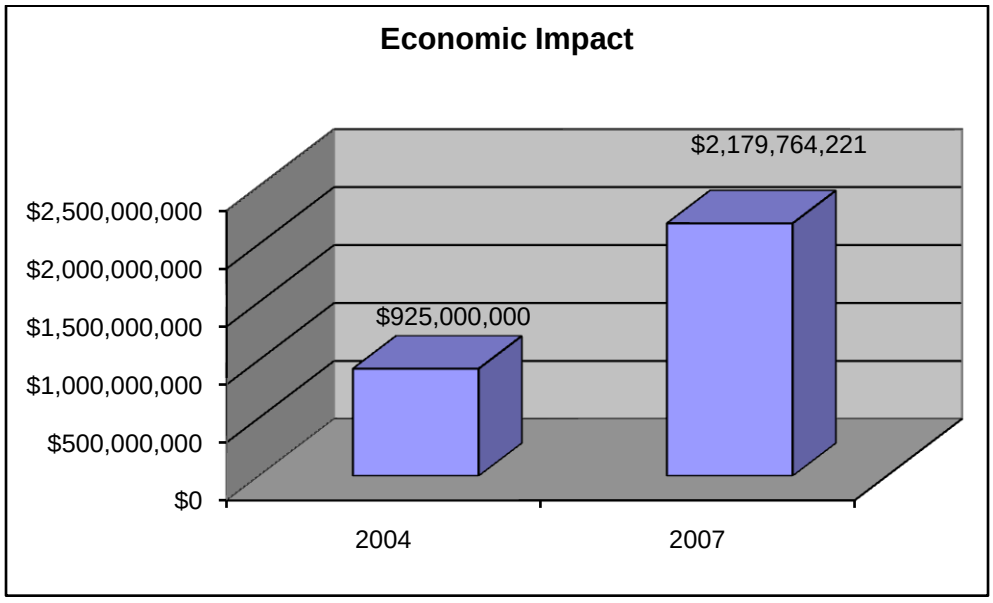


Figure 3: Economic Impact in Central Mass



Not only has the economic impact of the Central Massachusetts biomedical industry gone up, the number of employees and companies have gone up as well. The number of employees has gone up 117 percent from 7,576 employees in 2004 to 16,441 in 2007. The number of companies in Central Massachusetts went up 46 percent from 111 in 2004 to 162 in 2007. Also,

we found a total number of approximately 30 startup companies. Startup companies are defined as any company that has been established within the past five years including the time it has spent in an incubator. We cannot make a comparison to 2004 because the startup companies they included in their study are also included in ours. Below are the graphs to show the change in employees and companies in Central Massachusetts.

Figure 4: Central Mass Employees

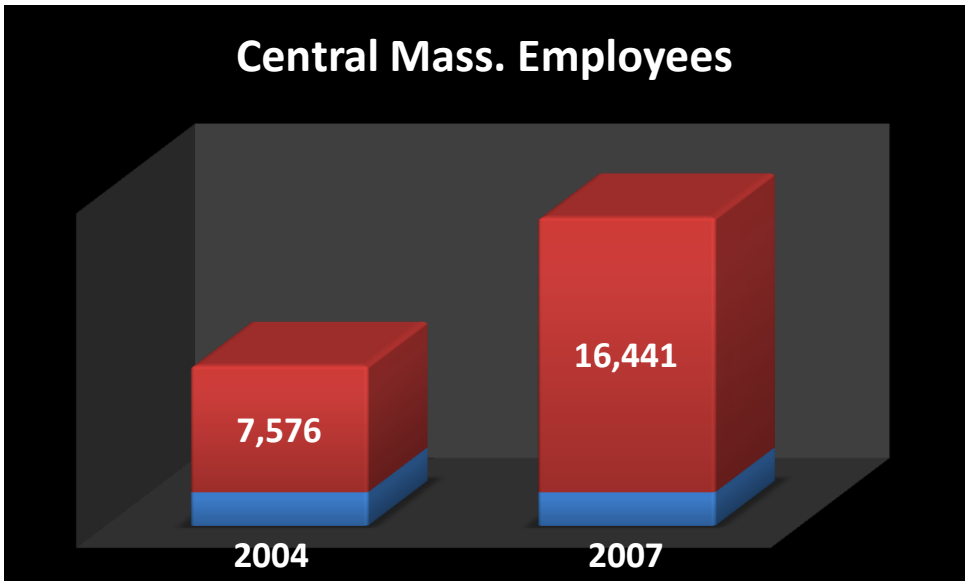
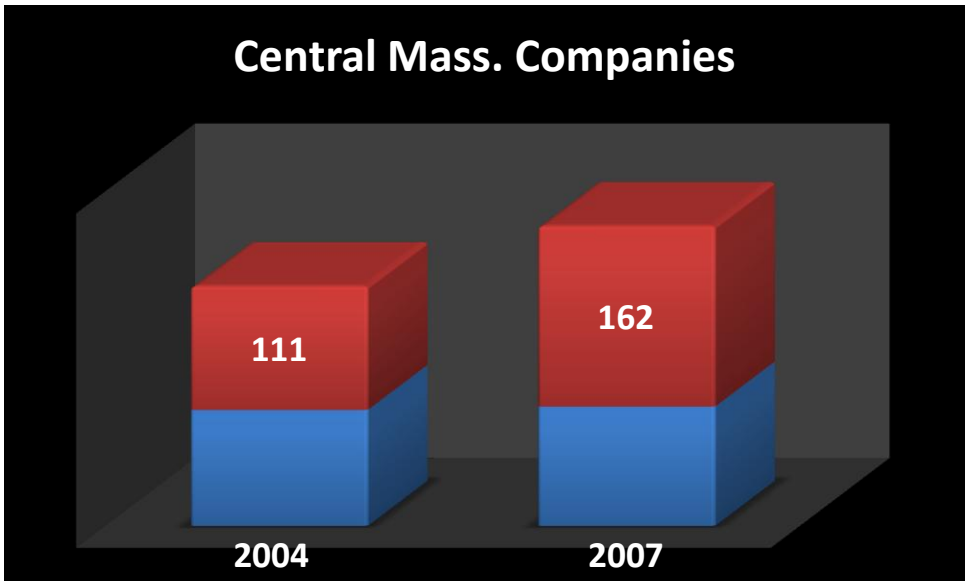


Figure 5: Central Mass Companies



4.2 – Economic Impact of the other Massachusetts Regions

As well as finding the economic impact of Central Massachusetts, we found the economic impacts of other regions within Massachusetts. We found the economic impacts of the Boston – Worcester corridor, the Boston area, Greater Boston, and the North Shore. This was done for a few reasons. One of the main goals of this project was to determine the economic impact of the Boston – Worcester corridor. In order to do this we needed to research the Boston and Greater Boston areas which are part of the corridor. We also studied these areas so that we can compare them to each other and determine what percentage of the industry they make up.

4.2.1 – Boston & Greater Boston

We define the Boston area as Boston and Cambridge. Greater Boston is the major cities surrounding the Boston area that are within route 95. The Boston and Cambridge area has the highest concentration of biomedical companies and employees. It is the epicenter and birth area

of the Massachusetts biomedical industry. The Boston area has about 184 companies and 16,478 employees. It has an average FTE cost of about $158,000 which results in an economic impact of approximately $2.6 billion. The Greater Boston area has about 254 companies and 16,000 employees. We did not find the average FTE cost and economic impact due to time constraints but that did not greatly affect the numbers for the Boston – Worcester corridor.

4.2.2 - Boston - Worcester Corridor

As defined before, the Boston – Worcester corridor is Boston, Cambridge, Greater Boston, Worcester County, and everything within route 9, 2, 190 and the Mass Pike. We used the same methodology as before to find the number of companies and employees, the average FTE costs, and the economic impact. Within this area there are about 690 companies and 46,759 employees. The average FTE cost was $154,918, which results in an $8.8 billion economic impact.

4.2.3 – North Shore

The North Shore is a rapidly growing area for the biomedical industry. It has the benefit of being located close to Boston without the heavy amounts of traffic and congestion. This is one of the many attractive features that bring in biomedical companies into the North Shore. It has about 82 companies and 5,400 employees. The average FTE cost is $149,500 which results in an economic impact of $805 million.

4.3 – Regional Comparisons

As mentioned before, we are not trying to show that the different biomedical regions in Massachusetts are competing with each other. It is our intent to convey the necessity of these regions to work with each other in order to create a stronger Massachusetts biomedical industry. The reason we make these comparisons is to simply show the makeup of the industry and where the strong concentrations of biomedical companies and employees lie.

The first two charts compare the Boston – Worcester Corridor to the rest of Massachusetts. It contributes 62 percent of the companies and 56 percent of the employees in Massachusetts. According to expert opinion, these numbers are actually surprising. The numbers are lower than expected and the percentage of companies and employees in the "other" category are higher than anticipated. Although there is no past information to support this claim, the numbers and expert opinion suggests that companies are starting to spread out more in Massachusetts. Whether or not they cannot be determined until future information is acquired.

Figure 6: Regional Comparisons (Companies)

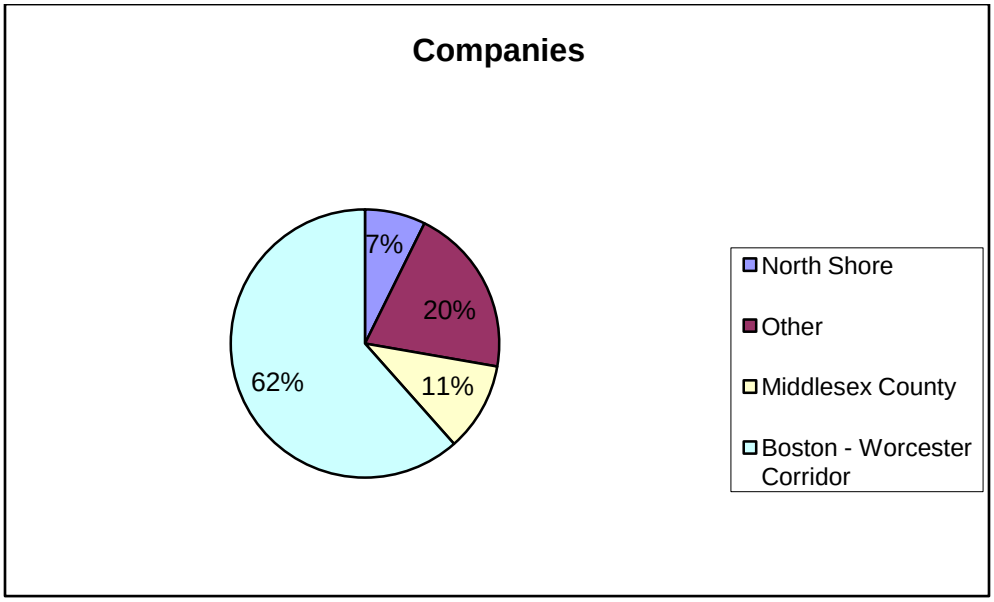
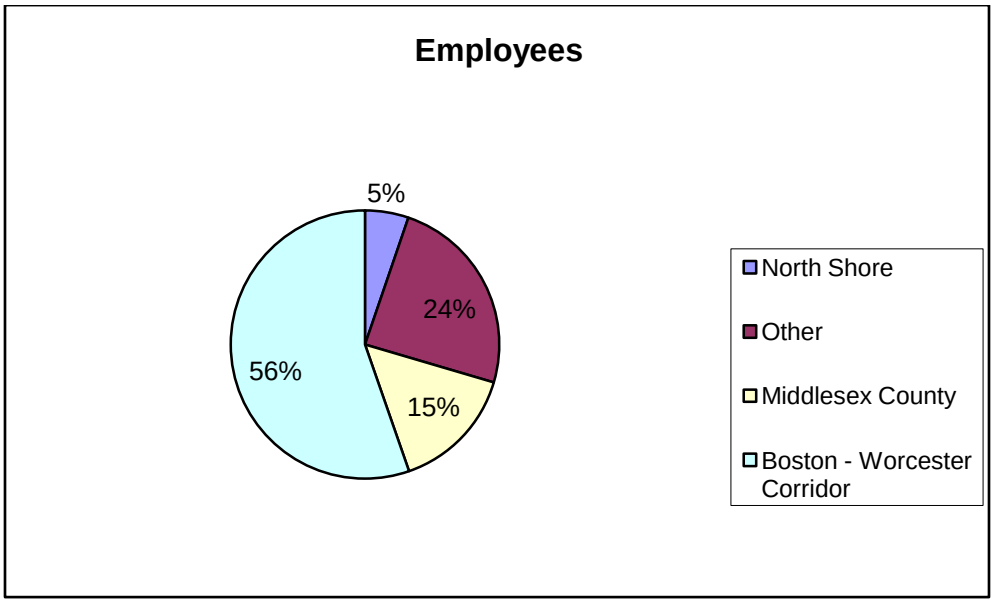


Figure 7: Regional Comparisons (Employees)



The next two charts compare the largest biomedical regions in Massachusetts. When looking at these numbers, the sizes of the different regions need to be considered. The company comparison looks relatively normal based on qualitative data from case studies as well as expert opinions. The Boston area and Greater Boston have the highest concentrations of companies. Boston is the birthplace of the Massachusetts biomedical industry and has always had the highest percentage of companies. Worcester County accounted for 24 percent of the companies and the North Shore accounted for 12 percent. Based on the size and age of these regions, these are not surprising numbers.

The employee comparison is a bit more deceiving. Worcester County accounts for 30 percent of employees, which is larger than Greater Boston and very close to Boston. Boston and Greater Boston have historically had the largest concentration of employees and has been unrivaled by other regions. The reason why the Worcester County percentage is so high is because it covers a much larger area than any of the other regions. If only Worcester and Boston

where compared then the numbers would look more accurate. The North Shore has the lowest percentage mainly due to the fact that it is a relatively new area for the biomedical industry. However, it is a rapidly expanding area and is expected to grow substantially in the near future.

Figure 8: Major Areas Company Comparison

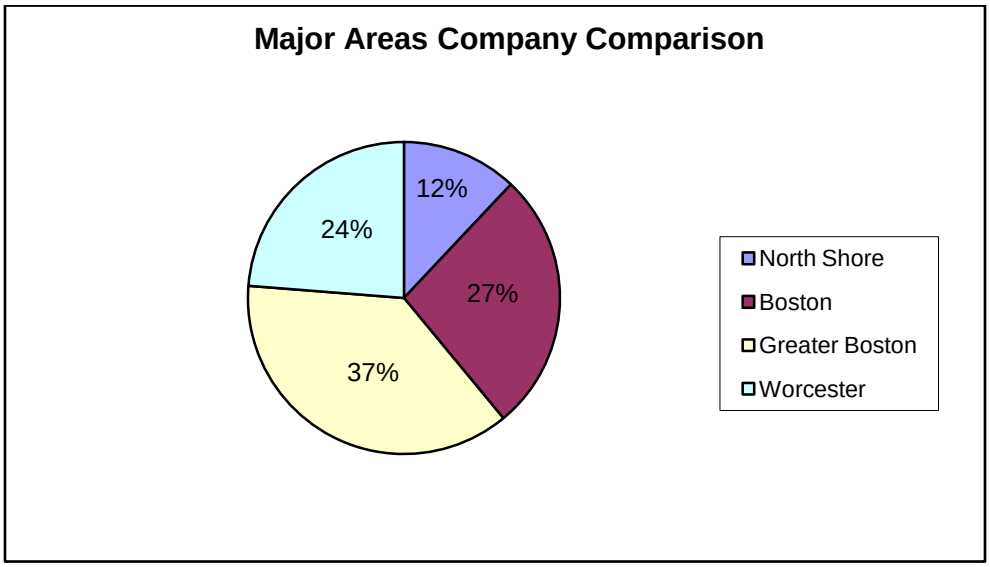
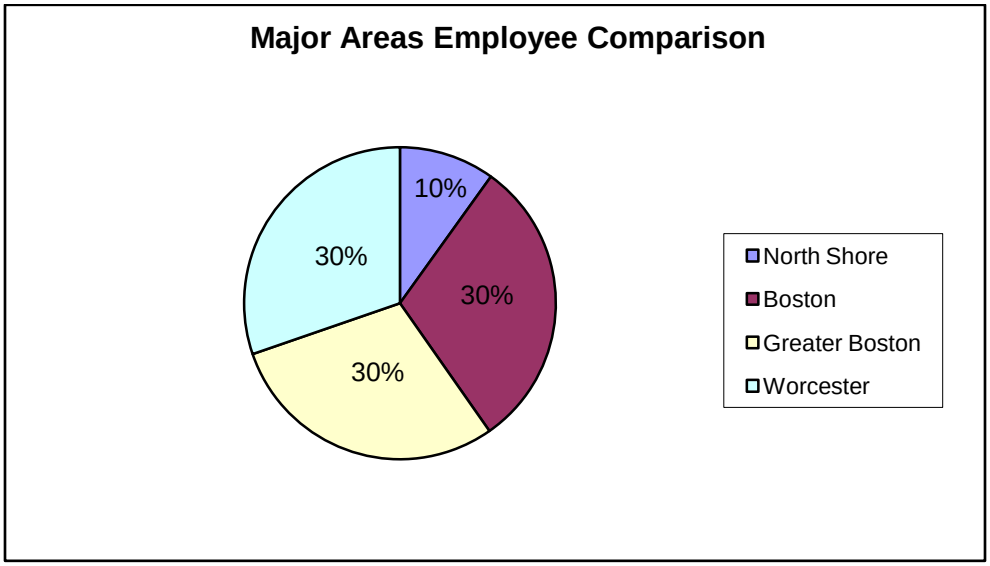


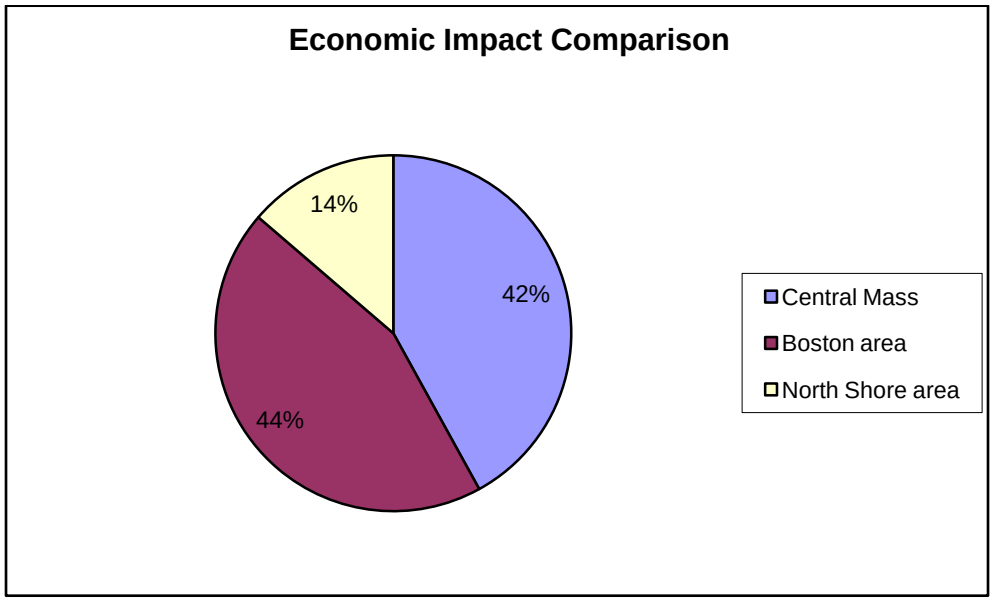
Figure 9: Major Areas Employee Comparison



The last chart compares the economic impact of the Central Massachusetts, the Boston area, and the North Shore. Many factors relating to the economic impact equation need to be

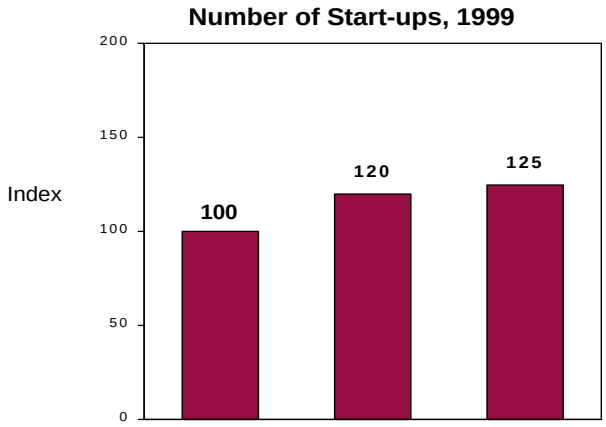
considered when comparing these numbers. As a reminder, the equation is the average FTE cost times the total number of employees in that particular region. The average FTE costs of these three regions were relatively the same. This is not surprising considering that we took the average costs of companies with similar functions, products, and operations. The number of employees between Worcester County and Boston area were relatively the same. Worcester accounted for 30 percent and Boston was 31 percent. Keeping in mind the size of the two different areas, it is not surprising that the number of employees were relatively the same. Therefore it only makes sense that the economic impacts were about the same. The North Shore has substantially less employees and therefore only accounted for 14 percent of the economic impact of the three regions.

Figure 10: Economic Impact Comparison



4.4 – Benchmark of the Massachusetts Biomedical Industry

The Massachusetts biomedical industry has been one of leading industries in the United States for years and continues to grow rapidly. In the Israel Biotechnology Strategy Project, many of the graphs show the Israeli biomedical industry compared to Massachusetts and even shows a chart with MIT and Harvard University on it. This implies that Massachusetts is a world recognized leader in the biomedical industry.



Start-ups	47	56	59

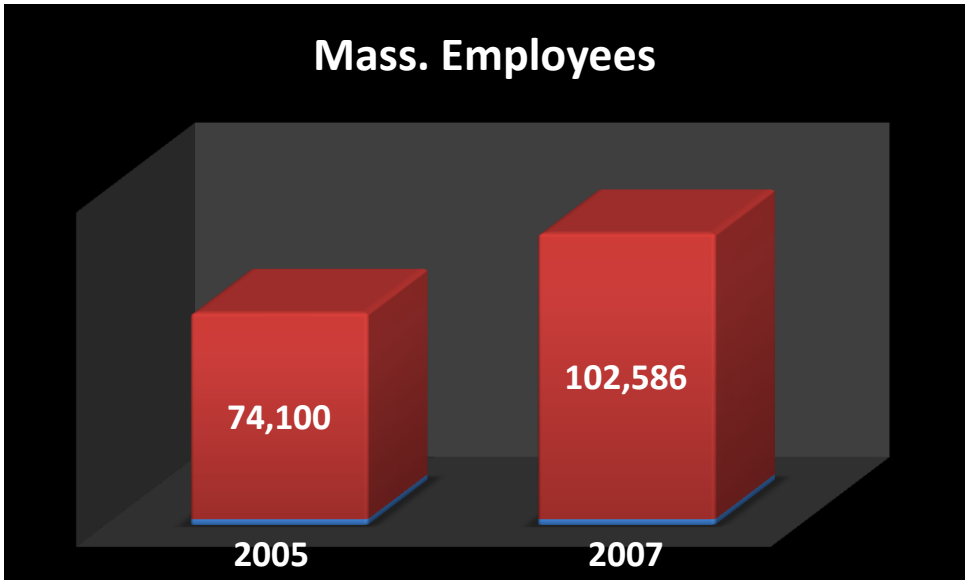
It may seem that Massachusetts has the leading biomedical industry in the United States, however, it remains second to California.

4.4.1 - Massachusetts Biomedical Industry Past and Present

The first step in benchmarking Massachusetts is showing the level of progress it has made in the past years. For employment, the industry employed a total of 71,600 people in 2001, 74,100 people in 2005, and 102,586 employees in 2007. Between 2001 and 2005, the number of

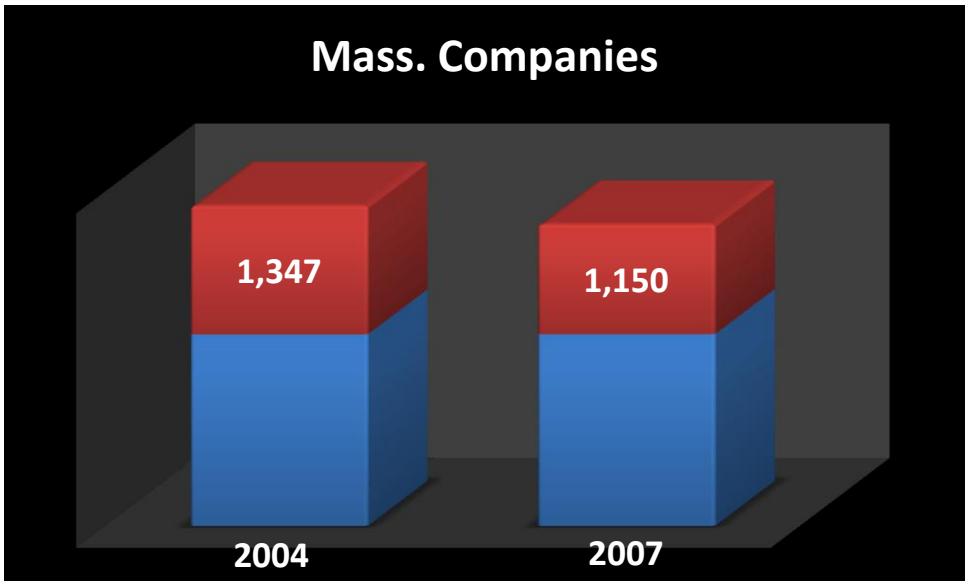
employees increased by 3.5 percent and between 2005 and 2007 it increased by 38.4 percent. The graphs below illustrate these changes.

Figure 11: Massachusetts Employees



The number of biomedical companies in 2004 was 1,347 (Schafer 2004) and about 1,150 in 2007 (PricewaterhouseCoopers). There was a 14.6 percent decrease between these dates. It is not uncommon for the number of biomedical companies to go down in number because mergers and acquisitions of companies are a frequent occurrence in this industry. Although there is no evidence to show this is what actually happened, it is a high possibility.

Figure 12: Massachusetts Companies



4.4.2 - State Comparisons

As mentioned before, Massachusetts has one of the leading biomedical industries in the United States. California remains number one in many different aspects, but Massachusetts continues to be considered one of the best states for the industry. The following section compares Massachusetts with some of the top leading states in six different areas. These areas are commonly used metrics in benchmarking the biomedical industry and where provided by the SuperCluster report done by PricewaterhouseCoopers.

4.4.2.1 - Funding

One of the largest sources of funding to the biomedical industry is the National Institutes of Health (NIH). The NIH provides many states with funding towards their biomedical or life science industries and usually allocates its money based upon three different qualifications. The NIH "looks for grant proposals of high scientific caliber that are relevant to public health needs that are within the NIH Institute and Center's priorities." It "encourages investigator-related

research across the spectrum of its mission." Also, the projects the individual or institution is conducting must be unique in the sense that they have never been done before. Based on these qualifications here are the rankings of the states that received the most funding from the NIH. (U.S. Department of Health & Human Services 2008)

Figure 13: NIH Funding & Grantee

NIH Funding Per Capita 2005

	(dollars)
Mass	353
Maryland	316
Connecticut	131
Washington	129
N. Carolina	124
Rhode Island	123
Pennsylvania	117
Vermont	108
New York	105

PricewaterhouseCooperss: SuperCluster

NIH Grantee States 2005

	(millions)
California	3,301
Mass	2,273
New York	2,021
Maryland	1,764
Penn.	1,452
Texas	1,150
N. Carolina	1,078
Washington	813
Illinois	734

PricewaterhouseCoopers: SuperCluster

Per capita, Massachusetts came in first for NIH funding in 2005 but in terms of total funding to the state in came in second, behind California. In 2007, NIH funding went down in both California and Massachusetts. California went down $138 million from 2005, which is a 4.18 percent decrease, and Massachusetts went down $37 million, which is a 1.62 percent decrease (National Institutes of Health (NIH) 2007). The difference between Massachusetts's NIH funding and California's state funding in 2007 was $927 million and in 2005 it was approximately $1 billion, which suggests that the gap is getting smaller and Massachusetts is slowly gaining more dominance over California in the biomedical industry (PricewaterhouseCoopers).

Another common economic indicator and comparison tool for most industries (as opposed to NIH funding which is usually associated with the biomedical industry) is venture capital. Venture capital directly correlates with the growth of a nation, industry, or business, in

the sense that a lot of it goes towards the development of new companies and research. An increase in new companies results in an increase in employment, new products, and economic contributions to the company's home state or country. Below is the state ranking for venture capital investment in the biomedical industry.

Figure 14: Venture Capital

Venture Capital 2006 (Approximate)

	(millions)
California	$3,300
MA	$1000
PA	$500
New Jersey	$400
Washington	$400
Maryland	$300
Colorado	$250
Minnesota	$250
N. Carolina	$200

PricewaterhouseCoopers: SuperCluster

4.4.2.2 – Employment

Having a competent and qualified workforce is one of the competitive advantages Porter describes in his essay. The competitive advantages mentioned in the section on Porter, could be applied to different levels including state and corporation, which is why employment is an important indicator of how well an industry is doing. Although we do have more updated information on employment for Massachusetts and California, we have information from 2005 for several of the other leading biomedical industries. Below are the rankings for biomedical

employment by state in 2001 and 2005. It is labeled as Life Science Employment, but, in this case, the terms are synonymous.

Figure 15: Life Sciences Employment

Life Sciences Employment

	2001	2005	Difference	% Change
U.S.	1,739,200	1,842,400	103,200	5.9%
California	247,400	260,700	10,900	5.4%
New York	120,500	122,800	2,300	2.0%
New Jersey	113,400	108,300	-5,100	-4.5%
Mass	71,600	74,100	3,300	3.5%
N. Carolina	50,500	59,500	9,000	17.7%

PricewaterhouseCoopers: SuperCluster

In 2007, Massachusetts employed approximately 100,000 people within the biomedical industry. This is still lower than the biomedical employment in New Jersey, New York, and California in 2005. Assuming that California and New York's biomedical employment continued to grow over the years, it is a good possibility that Massachusetts is still below them in the rankings. However, based on the same assumption that these states are continuing their growth trends, it is also possible the Massachusetts grew to be larger than New Jersey.

4.4.2.3 Education

As mentioned before, having an educated and qualified workforce can give a company, state, or even country, a competitive advantage over its competitors. That being said, obviously education is an important part in creating this caliber of a workforce. Massachusetts has always

been an epicenter of education in the world and holds some of the most prestigious colleges. Education is one of Massachusetts' strongest assets and it shows even within the biomedical industry. According to the PricewaterhouseCoopers "SuperCluster" report on the life science industry and the National Science Foundation, Massachusetts came in first for the number of degrees given out in the biology, chemistry, and chemical engineering fields. Here are the rankings of states for these degrees.

Figure 16: Life Sciences PhDs

Life Sciences PhDs Granted per 100,000 People

	Biology	Chemistry	Chem. Eng.
MA	6.51	2.05	0.90
Maryland	3.88	0.45	0.30
New York	3.13	0.72	0.28
N. Carolina	3.10	0.92	0.16
PA	2.22	0.89	0.48
California	2.05	0.81	0.28

PricewaterhouseCoopers: SuperCluster

4.4.2.4 - Biotechnology

Although biotechnology is not the same as biomedical, it is in fact a subsection of it and comprises the majority of the industry. Below is a comparison chart done by Ernst & Young on the biotechnology industries of different regions in the United States. It provides comparisons of many of the metrics used to benchmark any industry and gives a good picture of how well the New England area is doing in the U.S. biotechnology market. This does not effectively show Massachusetts place within the biotechnology market which was the original goal but it does at

least give an idea of how well it is doing considering that it has the strongest biomedical/biotechnology industry in the region. (Note: We took out two sections to reduce space and because they were not pertinent to this project)

Figure 17: Financial Highlights of U.S. Biotech Company

Selected 2006 U.S. biotechnology public company financial highlights					
[by geographic area, (US $m), percent change over 2005]					
Region	**# of Public Companies**	**Market Capitalization 31.12.06**	**Revenue**	**R&D**	**Total assets**
SF Bay Area	69	$145,553	$17,688	$7,485	$31,678
	0%	10%	15%	65%	-7%
New England	60	62,936	10,384	3,919	26,216
	3%	5%	16%	31%	4%
San Diego	38	20,916	3,252	1,432	8,589
	3%	6%	18%	32%	8%
New Jersey	28	28,556	1,747	802	3,196
	-3%	71%	23%	10%	-13%
Mid-Atlantic	23	17,111	2,061	1,270	7,210
	15%	13%	8%	11%	10%
Southeast	19	5,301	544	271	1,423
	0%	-25%	-64%	-34%	-53%
New York	17	8,893	1,373	685	3,533
	13%	25%	97%	6%	4%
Mid-West	8	1,161	121	90	342
	-11%	-28%	16%	-10%	7%
Pacific NW	15	4,928	196	521	1,245
	0%	22%	17%	19%	-9%
LA/Orange County	11	81,585	14,692	4,898	32,946
	0%	-18%	14%	94%	9%
North Carolina	9	2,017	326	191	735
	0%	-2%	-11%	-14%	2%

(Ernst & Young)

We have highlighted areas of importance to more easily compare New England to other regions. There are a couple of things to notice when looking at this chart. First, although it comes in third for almost all of the categories, regions in California are the only ones that outrank it. This suggests that Massachusetts comes second only to California in many of these areas. Second, New England has the same growth rate for the number of public companies as all the regions in California, which suggests that Massachusetts is growing at a similar rate.

4.4.3 - Global Biotechnology Industry

Using the economic metrics provided by the Ernst & Young report, it is apparent that the global biotechnology industry is continuing to grow. It is not apparent as to how fast the industry has been growing or how much it has grown over the years from this data, but it does show that it has been both growing and growing fast. Global biotechnology revenues went up 14 percent between 2005 and 2006. R & D expenditures went up 33 percent mainly due to strong emerging industries such as the ones in China and India. The number of employees went up 10 poercent and the number of companies went up .3 percent. The chart below provided by Ernst & Young displays these figures.

Figure 18: Growth in Global Biotech

Growth in global biotechnology, 2005 - 2006			
Public company data:	2006	2005	Change
Revenues (US $m)	73,478	64,213	14%
R&D expense (US $m)	27,782	20,934	33%
Net loss (US $m)	5,446	4,039	35%
Number of employees	190,500	173,110	10%
Number of companies:			
Public companies	710	673	5%
Public and private companies	4,275	4,263	0.3%

(Ernst & Young)

In chapter two, we analyzed the global biotechnology industry using Porter's Competitive Advantage. Due to a lack of sufficient information, we were not able to organize this section in the same manner. It does, however, provide key metrics that are commonly used in benchmarking the biotechnology industry. Once again, Ernst & Young who is a trusted source for financial and economic data provided these metrics and their respective charts.

4.4.3.1 - Financial & Economic Metrics

Below is a similar chart as above comparing some of the financial metrics between the U.S., Europe, and the Asia-Pacific region.

Figure 19: Global Biotech at a Glance

Global biotechnology at a glance in 2006				
Public company data	Global	U.S.	Europe	Asia-Pacific
Revenues (US $m)	73,478	55,458	11,489	3,289
R&D expense (US $m)	27,782	22,865	3,631	401
Net loss (US $m)	5,446	3,466	1,125	331
Number of employees	190,500	130,600	39,740	12,970
Number of companies				
Public companies	710	336	156	136
Public and private companies	4,275	1,452	1,621	737

(Ernst & Young)

The U.S. continues to be the leader in the global biotechnology industry in every way except one. Its revenues, R & D expenses, and number of employees are significantly higher than the other two regions. Whether or not its growth in these areas is higher or even significant is unknown due to the lack of past data. It is possible, however improbable, that the Asia-Pacific region's growth rates are higher due to its expanding prominence within the global biotechnology industry.

Financing is also a largely used metric in benchmarking any industry. A country's openness to others based on governmental policies, is one of Porter's competitive advantages. He believes that it is important for a country to have favorable economic policies towards outsiders in order to gain the types of finances shown below. The following chart compares the U.S. and Europe in three areas of financing.

Figure 20: U.S. and Europe Financial

The year in Financing: U.S. and Europe 2005 and 2006, (US $m)						
	2006		2005		Change	
Type	U.S.	Europe	U.S.	Europe	U.S.	Europe
Initial Public Offering (IPO)	944	907	626	691	51%	31%
Follow-on and other offerings	16,067	3,069	10,740	1,577	50%	95%
Venture Financing	3,302	1,907	3,328	1,738	-1%	10%
Total	$20,313	$5,883	$14,694	$4,006	38%	47%

(Ernst & Young)

Although the U.S. has a higher percentage of IPO's between 2005 and 2006, it significantly lacks in the other two areas of financing compared to Europe. Its total financing also had a smaller percentage change compared to Europe. Once again, this is probably due to the increased governmental policies that are making it more difficult for companies to develop and produce more products.

4.4.3.2 – Educational Metrics and Patents

As mentioned in chapter two, education is a highly important metric and is essentially one of the comparative advantages Porter describes. It is especially important in the biotechnology industry where almost every job requires an extensive education within its fields. Patents are also a widely used metric in the biotechnology industry and are indicator of how many products are successfully being developed by companies within the industry. Below is a chart showing the rankings of countries based on these metrics. Scientific paper citations are usually associated with education as it is in the chart below.

Figure 21: Scientific Competitiveness

Scientific competitiveness: Selected indicators							
Country	Scientific paper citations		Share of global biotechnology patents		High school science proficiency	Growth in biotechnology patent applications	
	Value	Rank	Value	Rank	Rank	Value	Rank
U.S.	37,822	1	43.3%	1	20	1.5%	20
UK	7,565	2	5.3%	4	-	2.8%	19
Germany	7,497	3	9.6%	3	14	10.1%	6
Japan	6,298	4	14.1%	2	1	8.2%	9
France	5,172	5	3.6%	5	12	6.3%	14
Canada	4,194	6	2.7%	6	8	5.2%	16
Italy	3,363	7	1.0%	15	22	8.1%	10
Netherlands	2,665	8	1.7%	9	5	5.8%	15
Australia	2,273	9	2.1%	7	5	3.9%	17
Switzerland	2,168	10	1.4%	12	10	9.0%	8
China	1,481	13	1.7%	9	-	49.3%	1
India	789	below 20	0.8%	16	-	30.4%	2

(Ernst & Young)

The U.S. is at number one for both scientific paper citations and its share of global biotechnology patents. What is interesting to notice is that it is ranked 20th for high school science proficiency and its growth in biotechnology patent applications. According to the PricewaterhouseCoopers report on the Massachusetts "SuperCluster", one of the industries growing concerns is the proficiency students have in science at the elementary to high school levels. This seems to be the case for most of America judging by its ranking. Its ranking for growth in biotechnology

applications is no surprise considering that it has become increasingly harder to get patents due to government policies.

Europe is following a similar path as America in terms of its rankings. Europe's countries are highly ranked in the first two fields but fall short with education proficiency and patent growth. China and India on the other hand have experienced the complete opposite of Europe and America. Their share in global biotechnology patents and scientific paper citations is very low. Their growth in biotechnology patent applications is however ranked one and two. China was ranked at number one and India at number two. This is not surprising considering their governments have made great strides to reduce restrictions on patents and to ease the process of obtaining them.

4.4.3.3 – Global Alliances

The sharing of physical resources, products, and information is an essential part to the growth of the global biomedical industry. Not only does it benefit the industry, it benefits the consumers in the sense that alliances allow for more breakthroughs and products that will help people's daily lives. Alliances bring in more venture capital, information, resources such as educated labor, revenues, etc. The danger of alliances though is the decrease in competition, which Porter describes as an essential component to an industries growth. It also has the ability to hurt the development of startup companies in the sense that information becomes too widely available and susceptible to being stolen. Below is a chart showing Europe's share of alliances with the biotechnology industries in America and Asia.

Figure 22: Alliances by Regions

Share of alliances by region, 2001 - 2006						
Region	2001	2002	2003	2004	2005	2006
Europe-Europe	37%	34%	47%	41%	50%	49%
Europe-U.S./North America	56%	55%	43%	49%	40%	40%
Europe-Asia	7%	11%	10%	10%	10%	11%

(Ernst & Young)

As you can see, Europe maintains alliances primarily with itself and mostly with America after that. What is interesting to notice is the decrease in the share of alliances with America over the years. This could be due to Americas increasing patent restrictions and product approval policies. Asia has remained relatively the same over the years but it is more than likely to increase as it becomes a stronger entity within the global biotechnology industry.

4.5 - Forecasting

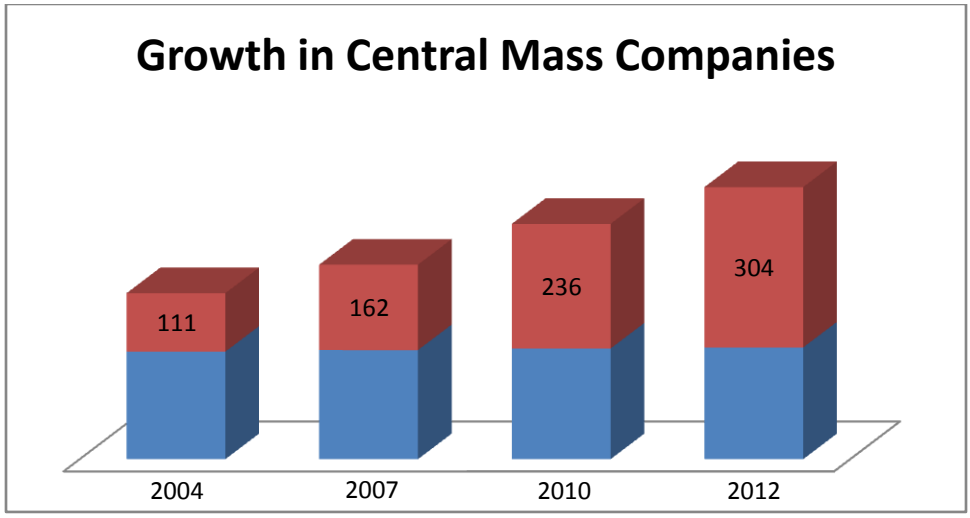
Using a simple linear equation and compounding, we determined the 2010 and 2012 data for the number of companies, employees, and economic impact of the Central Massachusetts biomedical industry. The original goal was to determine the 2012 data, but we included 2010 to show the linear progression from 2004 more effectively. We applied the same methodology to the Massachusetts biomedical industry, however, we could not forecast its economic impact because of the lack of data. No numerical forecasting was done for the United States and global biomedical industry for the same reason. The forecasted numbers represent a simple linear extrapolation, but it is treated in this report as the upper bound of growth these areas are expected to grow if we assume the growth rate remains the same. In reality, it is not likely for these industries to reach these levels, therefore we use qualitative data to develop a more realistic

growth forecast. The following sections only include brief descriptions of the charts provided. It is only meant to provide the numerical part of our forecasting process. Further analyses of the numbers are done in the following chapter.

4.5.1 – Central Massachusetts

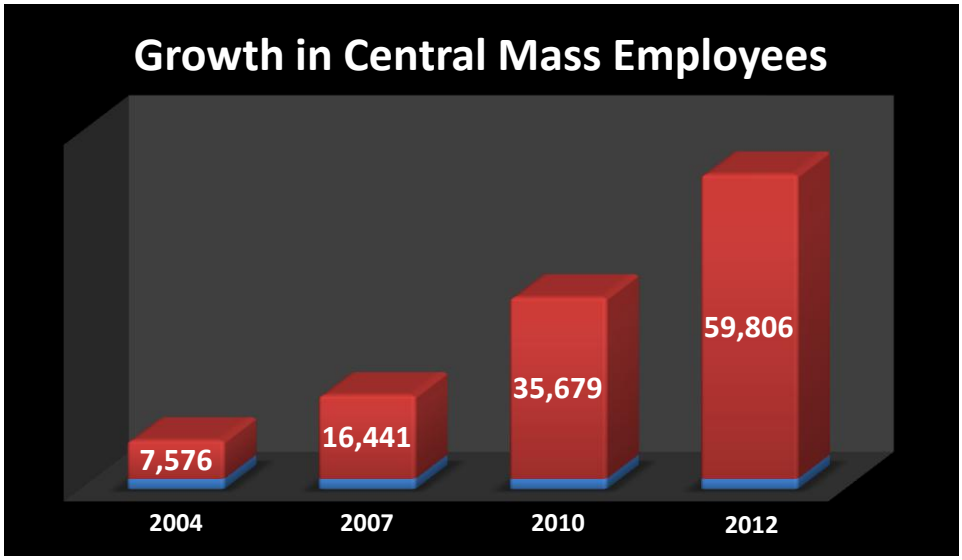
Based on our linear equation, the number of companies in Central Massachusetts will grow 46 percent in 2010 and 88 percent in 2012.

Figure 23: Forecasted Central Mass Companies



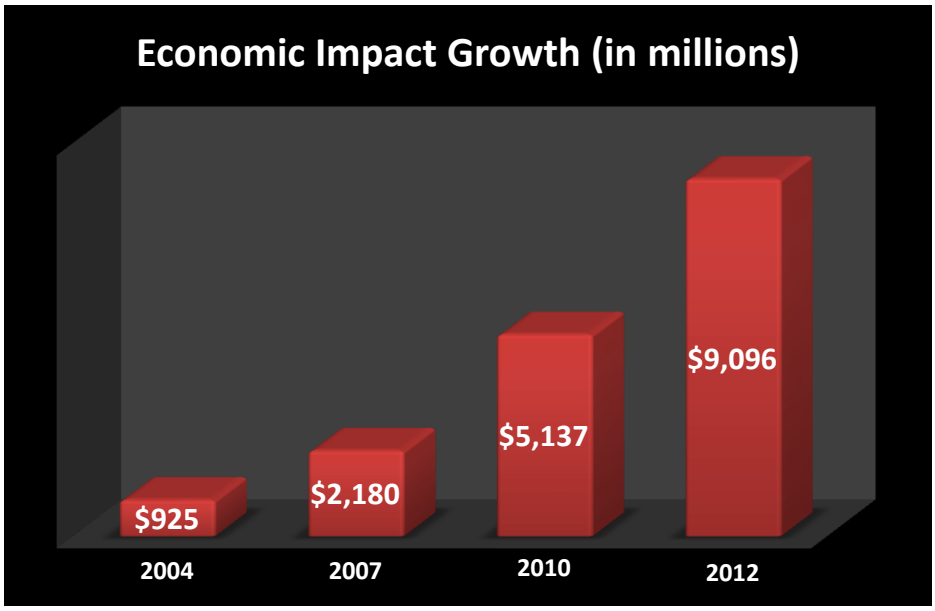
The number of employees in Central Massachusetts will grow 117 percent in 2010 (2.2 times the amount of 2007) and 264 percent in 2012.

Figure 24: Forecasted Central Mass Employees



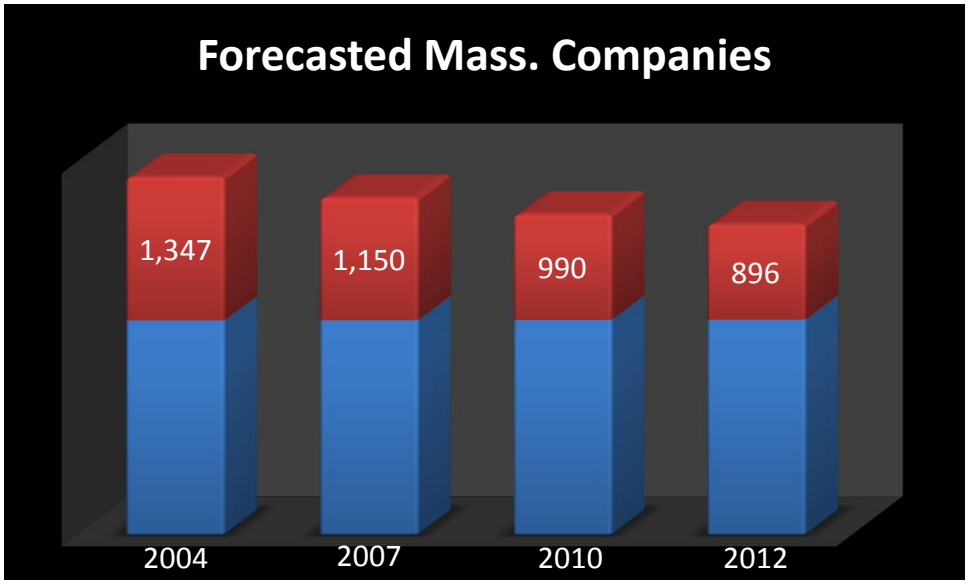
In 2010 the economic impact will grow to $5.1 billion (a 136% increase) which is more than double 2007. In 2012 it will grow 317 percent to about $9.1 billion.

Figure 25: Forecasted Central Mass Economic Impact



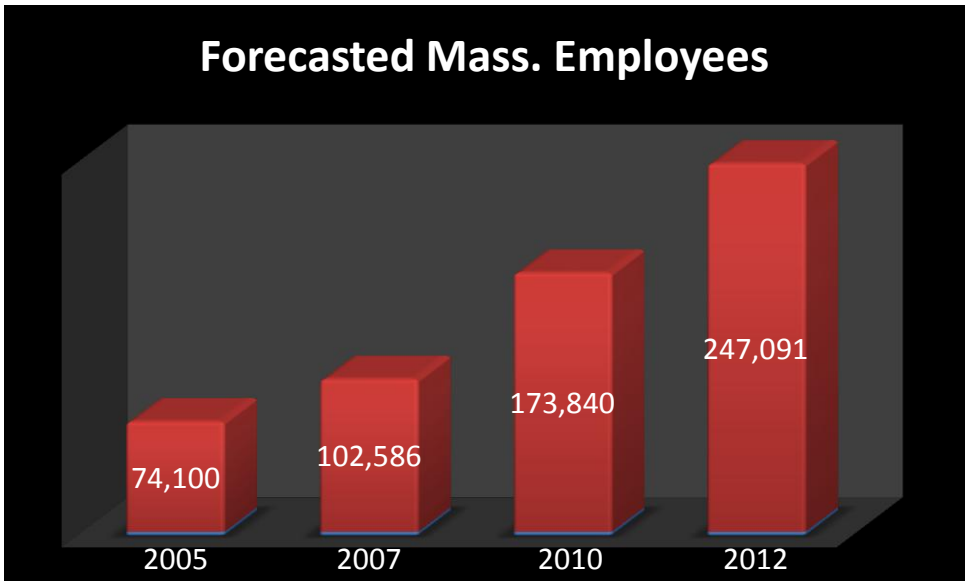
4.5.2 – Massachusetts

Figure 26: Forecasted Mass Companies



The number of companies dropped between 2004 and 2007 causing a negative growth rate. It is not uncommon for the number of companies to go down in this industry due to large number of mergers and acquisitions. It would, however, be doubtful for the number of companies to continue to decline based on the overall industry growth. Even though these numbers suggest the number of biomedical companies in Massachusetts will go down, we believe that it will do just the opposite. We analyze this further in the next chapter.

Figure 27: Forecasted Mass Employees



In 2010 the number of people employed in the Massachusetts biomedical industry will go up to about $174,000 in 2010 which is a 69.5 percent increase. In 2012 it will grow 141 percent to approximately $250,000.

4.6 – SWOT Analysis

We did a SWOT analysis for all the different levels of the project. That includes the Central Massachusetts, Massachusetts, and the global biomedical industry (U.S., Europe, and Asia Pacific). We used this information to further expand on our forecasting. The growth we found through linear projection is unrealistic and is intended only to show what would happen if growth remained the same. For a variety of reasons, however, that is not likely to occur. Therefore, we use the information in the SWOT analysis to determine how accurate the numbers are and how much the selected metrics of these industries will actually grow.

4.6.1 – Central Massachusetts

- Strengths
    - Large and prestigious academic community
    - Knowledgeable workforce
    - Large amount of companies and employees
    - Has biomedical incubators such as MBI
    - Away from Boston traffic
    - Comparatively lower living costs
- Weaknesses
    - Distance from the Boston area
        - Limited access to its resources
    - Insufficient K-12 life science education
- Opportunities
    - Planned stem cell research center at UMASS Medical in Worcester
    - Governor Patrick's life science initiative
- Threats
    - Decreases in NIH funding
    - Strict patent application process
    - Negative governmental drug pricing policies
    - Struggling U.S. economy
    -

4.6.2 – Massachusetts

- Strengths
    - One of the largest biomedical clusters in the world
        - Provides related and supporting industries

    - High levels of financing
        - Number one for NIH funding per capita (2nd by state)
        - Government, corporate, & private
        - Number 2 in the U.S. for receiving venture capital
    - 2nd in the U.S. for R&D expenses
    - Large amount of Employees & Companies
        - 4th in the U.S. for life science employment
- Weaknesses
    - High levels of traffic
    - Insufficient k-12 life science education
    - Decreased patent issuance
    - Expensive labor force
- Opportunities
    - Governor Patrick's 1 billion dollar life science initiative
- Threats
    - Decreasing NIH funding
    - Struggling U.S. economy

4.6.3 – Global

The following information is once again organized using Porter's Competitive Advantages

4.6.3.1 – America

- Strengths
    - Large amounts of capital
    - High internal demand
        - Large elderly population

    - Strong hold on the technology industry
        - One of the largest contributors to the growth of the biomedical industry
    - Largest amount of financing and venture capital
    - Large knowledgeable workforce
    - Has the largest and most prominent biotechnology clusters
    - Large amount of tax incentives
- Weaknesses
    - Strict patent application process
        - Decrease in patent applications
    - Strict trade laws
        - Low level of trade incentives
    - Decreased federal funding
    - Insufficient K-12 life science education
    - Problematic drug pricing policies
    - Decreasing overseas alliances
- Opportunities
    - Combating its own weaknesses
    - Creating alliances with Europe and especially China
- Threats
    - China's rapidly expanding biomedical industry
    - Europe's strong relations with other countries

4.6.3.2 – Europe

- Strengths
    - Strong inter-country relations through

        - Trade incentives
        - Pipelines & networking
        - Common currency
        - Lenient foreign entry policies
    - Large amounts of funding & venture capital
        - Second only to America
    - 17 large biomedical clusters between
        - U.K.
        - Germany
        - France
    - Most amount of alliances with foreign countries
- Weaknesses
    - None found
- Opportunities
    - Increased alliances with America and China
- Threats
    - America and the Asia – Pacific region

4.6.3.3 – Asia Pacific

- Strengths
    - Strong hold on underdeveloped niches
        - Stem cell, gene therapy, & traditional Chinese medicine
    - Improved patent laws
    - Large government funding for education and business development
    - Incubators & high tech zones
    - Improved foreign entry policies
    - Improved safety and environmental policies
- Weaknesses

    - Communist country
        - Makes it harder for foreign companies to establish businesses there which can reduce venture capital
        - Low trade incentives
    - Comparatively smaller labor interests in the biomedical industry
    - Patent laws are still not as effective as other countries
    - Still a young developing industry
- Opportunities
    - Improve patent, trade, and foreign entry policies and take advantage of its rapid growth
        - Create alliances with America and Europe
- Threats
    - Europe & America

4.7 – Forecasting Justification

As we discussed at the beginning of the previous section, the predicted numbers using a linear compounding equation are not a reliable or accurate portrayal of how well the biomedical industry will actually do. The numbers represent what we believe is the maximum growth the industry will see for that particular metric. Also, this assumes that the industry's growth rate will continually increase over that period of time. If those numbers are in fact accurate, then we can assume that the industry faces few problems and is constantly improving itself. It is likely that this will not occur, which is why we need to incorporate qualitative data and get a better picture of how much the industry will actually grow. Our key tools in doing this were the SWOT analysis, and expert opinions which we received through contacts and interviews, current events, and case studies.

All of the experts we contacted were agreed that the Central Massachusetts biomedical industry will grow in terms of companies and employees during the next five years. On the other hand, we looked at different resources, such as EBSCO, Scenario Thinking, and the U.S. Department of Labor Employment and Training Administration. These resources predicted that the economic impact for the United States biomedical industry will experience an increase of about 13-14 percent and employment of about 12-13 percent between 2006 and 2012.

From the SWOT analysis and case studies we learned that the Central Massachusetts biomedical industry is currently facing problems such as reduced NIH funding, decreased issuance of patents, increased governmental regulation of prices, and more (we will discuss more briefly in the next chapter). All of these lead us to believe that the growth rate of the Central Massachusetts will be higher than the rate for the United States in both economic impact and employment, but will be lower than the defined growth rate using the linear equation. Therefore we came up with the new growth rate by taking average of the United States' growth rates with our defined growth rates in Central Massachusetts. We applied this equation for all three categories: economic impact, employment, and number of companies.

4.7.1 – Central Massachusetts

Based on above equation, the number of companies in Central Massachusetts will grow 67 percent (10.7% annually) between 2007 and 2012.

Figure 28: Central Mass Companies (Adjustment)

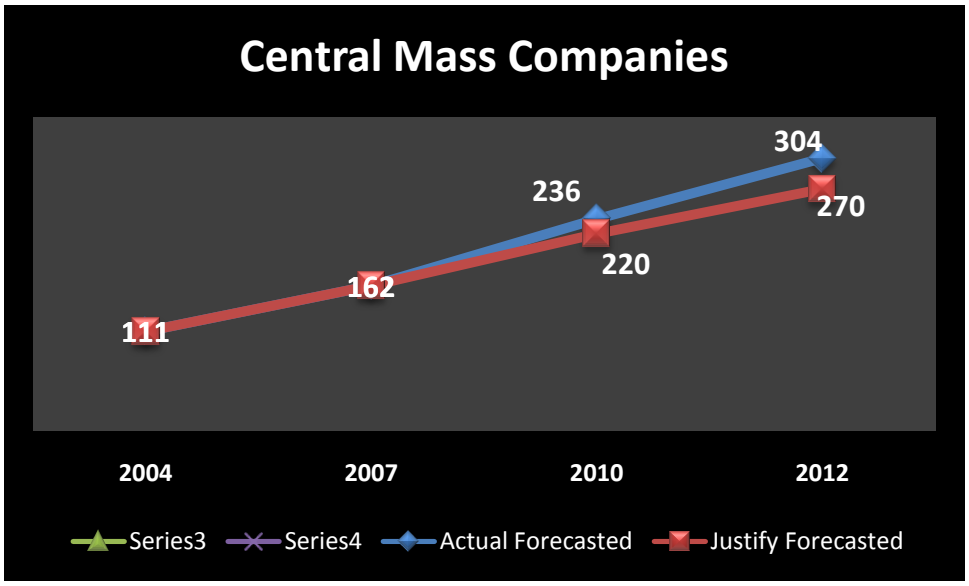
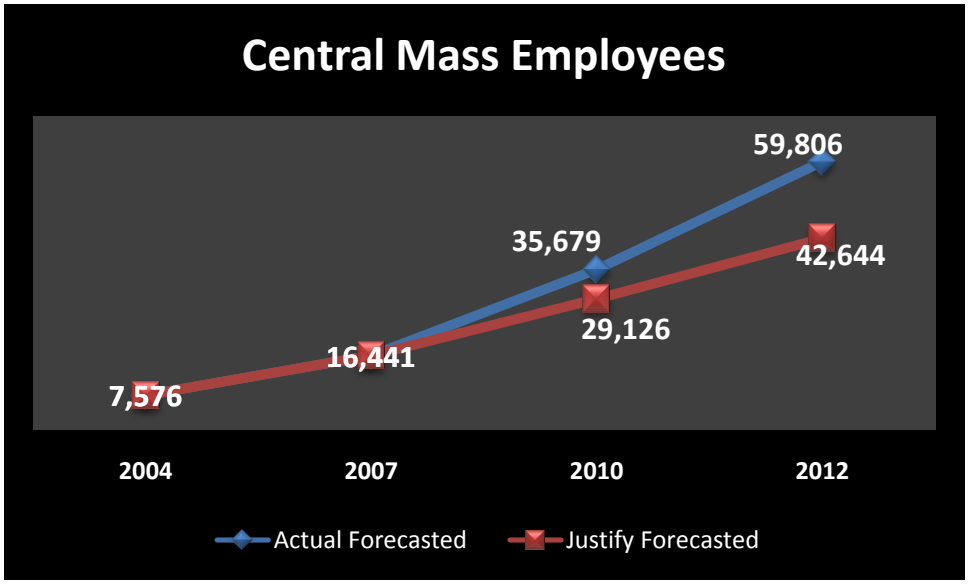
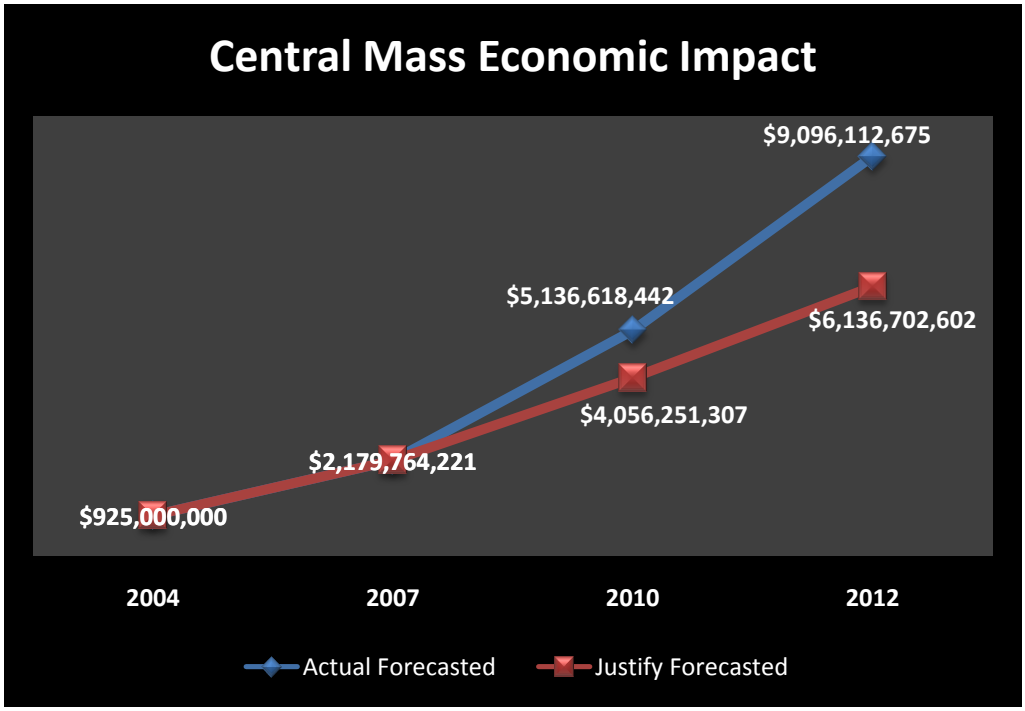


Figure 29: Central Mass Employees (Adjustment)



Between 2007 and 2012, the number of employees in Central Massachusetts will grow 159 percent (21% annually).

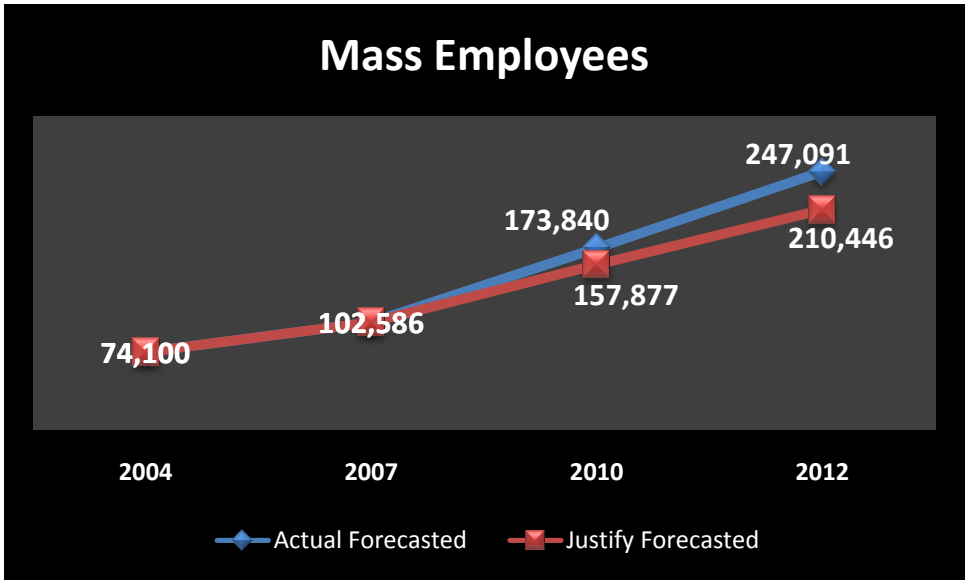
Figure 30: Central Mass Economic Impact (Adjustment)



The economic impact in Central Massachusetts will grow 182 percent (23% annually) to about $6.1 billion in 2012.

4.7.2 – Massachusetts

Figure 31: Mass Employees (Adjustment)



Using the equation, the number of employees will increase by about 105 percent (15.5% a year) by 2012. That is a total of 210,466 employees. The U.S. employment growth rate was around 13 percent so we are fairly confident that this is a reasonable estimate. We cannot effectively predict the number of companies because the original growth rate was negative causing the numbers to go down. However, based on our qualitative information we believe that the number of companies in Massachusetts will increase beyond the 2005 number, which was 1,347.

5.0 – Conclusions and Recommendations

This chapter serves two purposes. The first purpose is to make conclusions on our forecasting. We already determined the numerical portion of the forecasting. The next step is to use the qualitative information we have gathered to make better forecasts of the different industries. The second purpose of this section is to make recommendations on how the industries can improve.

5.1 – Forecasting Conclusions

5.1.1 – Central Massachusetts

All of the experts we contacted were agreed that the Central Massachusetts biomedical industry will see substantial growth in the coming years. When contacting these experts we mainly asked them how they feel the overall industry is doing and what they believe will happen to it in the future. We specifically talked about if the number of companies and employees will increase over the years. We did not ask about what they think the economic impact of the Central Massachusetts will do because we did not have the information at the time and it was a relatively unfamiliar subject to them. The experts all agreed that Central Massachusetts biomedical industry will see substantial growth in terms of companies and employees. Using this information and the quantitative data we forecasted, we determined that the industry will see relatively high growth rates in employment and number of companies. Based on the equation we used to find the economic impact, we figured out that if the number of employees in the region increases, the economic impact will increase with it. That means we should see a substantial growth rate for the economic impact of Central Massachusetts as well.

We also gained confidence that the industry will grow because of Governor Patrick's life science initiative. Not only will Central Massachusetts receive a good portion of the funding, it will be receiving a state of the art stem cell research center. This will be located in Worcester at UMASS Medical School. Stem cell research is a hot topic in America and a lot of states will not allow it due to moral issues presented by the public and some government representatives. Many companies on the other hand are very eager to do research on this subject. Having a stem cell research center in Worcester will probably bring a lot of biomedical companies and labor into the area. On the other hand, growth rates from other studies suggest that our numbers will not be as high. Even though these studies were done on the United States biomedical industry, they give us more of an idea of what the actual growth rates will be. Economic impact for the United States biomedical industry has a growth rate of about 13-14 percent and employment has around 12-13 percent.

From the SWOT analysis and case studies we did learn that the Central Massachusetts biomedical industry is currently facing some problems. Patents are becoming harder to get which inhibits a lot of R&D and the production of new products. It has been said that life science education has been less than satisfactory in grades K-12. NIH funding is going down everywhere. Price regulations put in place by the government have made it difficult for pharmaceuticals to produce drugs at a profit and the overall economy is declining. All of these problems are not specific to Central Massachusetts. They are general problems the United States biomedical industry is facing and every state and region is feeling its affects. It is very possible that Central Massachusetts has only incurred a small amount of these problems which leads us to believe that the growth rates will be relatively high.

Based on all of this information, we believe that the growth shown in the forecasting graphs is relatively accurate. The numbers, expert opinion, and current events lead us to believe this. This is not to say that an industry can go without its problems. The problems discussed above suggest that the industry will not see the growth suggested by the numbers in the graphs. Although possibly minor for this region, they are factors that would inhibit the growth of the industry. Instead of the number of companies growing 88 percent between 2007 and 2012, which is what the graph shows, it is more likely that it will grow around 67 percent (10.7% annually). That is a total of 270 companies in 2012. We arrived at this number by taking average of the United States' growth rates with our defined growth rates in Central Massachusetts. Because the problems associated with the Central Massachusetts biomedical industry are relatively minor and the numbers and expert opinion suggest substantial growth, the actual company, employee, and economic impact growth should be in the high range. We applied this same method for employees and the economic impact. Employment will grow around 159 percent (21% annually) which results in a total of 42,644 employees by 2012. Also, the economic impact will grow approximately 182 percent (23% annually). That is a total of $6.1 billion by 2012.

Even though these growth rates are significantly higher than those of the United States, they are not surprising considering Massachusetts has had higher growth rates in this sector than the United States for several years now. The annual growth rates in Central Massachusetts for economic impact and employment are almost two times larger than the United States. As we will discuss in the next section, Massachusetts' growth rate for biomedical employment is almost twice as large as that of the United States. Based on this we believe that our adjusted forecast is relatively accurate.

5.1.2 – Massachusetts

A lot of the information we received on Central Massachusetts was the same as what we got for Massachusetts. Expert opinions and case studies suggested that the Massachusetts biomedical industry will see a lot of growth within the next five years. It will also gain more benefit from the governor's life science plan that the Central Massachusetts industry will receive. On the other hand, the problems listed for Central Massachusetts are the same for Massachusetts as a whole. The difference is that the Massachusetts biomedical industry is affected more heavily by their impacts. On top of that, other unique problems exist for Massachusetts such as the traffic problems that exist in Boston.

Based on this data we believe that the Massachusetts biomedical industry will in fact see a lot of growth in the next five years but not to the extent Central Massachusetts will. Using the same methodology we used to predict the new growths for Central Massachusetts, we found a more accurate prediction of the Massachusetts biomedical industry. Because the problems are more severe for Massachusetts as a whole, it is more likely that the actual growth will be below these adjusted numbers.

5.1.3 – America

Since there was not enough numerical data to make mathematical predictions like the ones for Central Massachusetts and Massachusetts, all of the predictions made for the United States biomedical industry where made using qualitative information. Currently, the United States biomedical industry is the largest and strongest in the world. It has the largest amount of capital, a high level of internal demand, a strong hold on the technology industry, a large knowledgeable workforce, the largest and most prominent biotechnology clusters, and it has the

highest amount of financing and venture capital. These are the competitive advantages the United States has which make it the number one biomedical industry. They help steer the flow of trade in the American biomedical industry which is why it is the most profitable.

Despite America's numerous competitive advantages, it is facing some serious problems and if the government does not do something about it, it is quite possible that America will lose its ranking as the number one biomedical industry. China's biomedical industry is growing faster than any other countries. It has made several reformations and initiatives to grow its biomedical industry and it has seen a lot of success because of it. They also have numerous competitive advantages which are threatening to America's industry. They have the largest labor force in the world and with government programs, funding, and incentives; they are becoming very well educated in the life sciences. They have made a dramatic shift from manufacturing to R&D. Also, the government is making stronger patent laws and policies which used to be a major issue in China. If the America government does not start changing many of its policies that negatively affect the biomedical industry, there is a strong possibility that China will exceed us and become the number one biomedical industry in the world.

There is also a good chance that Europe will one day beat out America if we do not start changing our policies. Europe has liberal foreign entry and trade laws and has several tax incentives to encourage trade. Because of these policies, Europe has developed strong networking abilities and has more alliances between countries than both American and the Asia-Pacific region. If China does in fact obtain the number one biomedical industry in the world, it is more than likely that Europe will become a close second because of their trading policies, networking abilities, and alliances.

5.2 – Recommendations

A lot of the recommendations made in this section apply to all three of the industries discussed in the previous section. The same recommendations are applicable to Central Massachusetts, Massachusetts, and the United States because they share a lot of the same problems. The common problems are decreased NIH funding, stricter patent application policies, drug-pricing policies, and insufficient levels of life science education in grades K-12. A lot of these problems need to be addressed by the federal government but some of them may be able to be dealt with through the Massachusetts state government.

The federal government should increase funding for education, business development, and R&D through their NIH program as well as others. It needs to find a balance between putting price caps on pharmaceutical and medical device products and letting the companies set their own prices. If the companies cannot produce a profit then the public cannot benefit from their new products. On the other hand, if the products are too expensive then the public would not be able to benefit from them anyway. This is why a balance needs to be found between regulating prices and letting companies set their own prices. The federal government should also change their patent and drug development policies so that companies can make a faster transition from R&D to production. Also both the federal and state government should create stronger life science educational programs for grades K-12. Massachusetts specifically should find ways to solve the transportation issues. Public transportation programs and better commuter rail systems are a couple of options to help reduce traffic.

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Appendix A: Central Massachusetts

Map 1: Actual Central Massachusetts

This map defines the region of Massachusetts presented by the Department of Business and Technology.

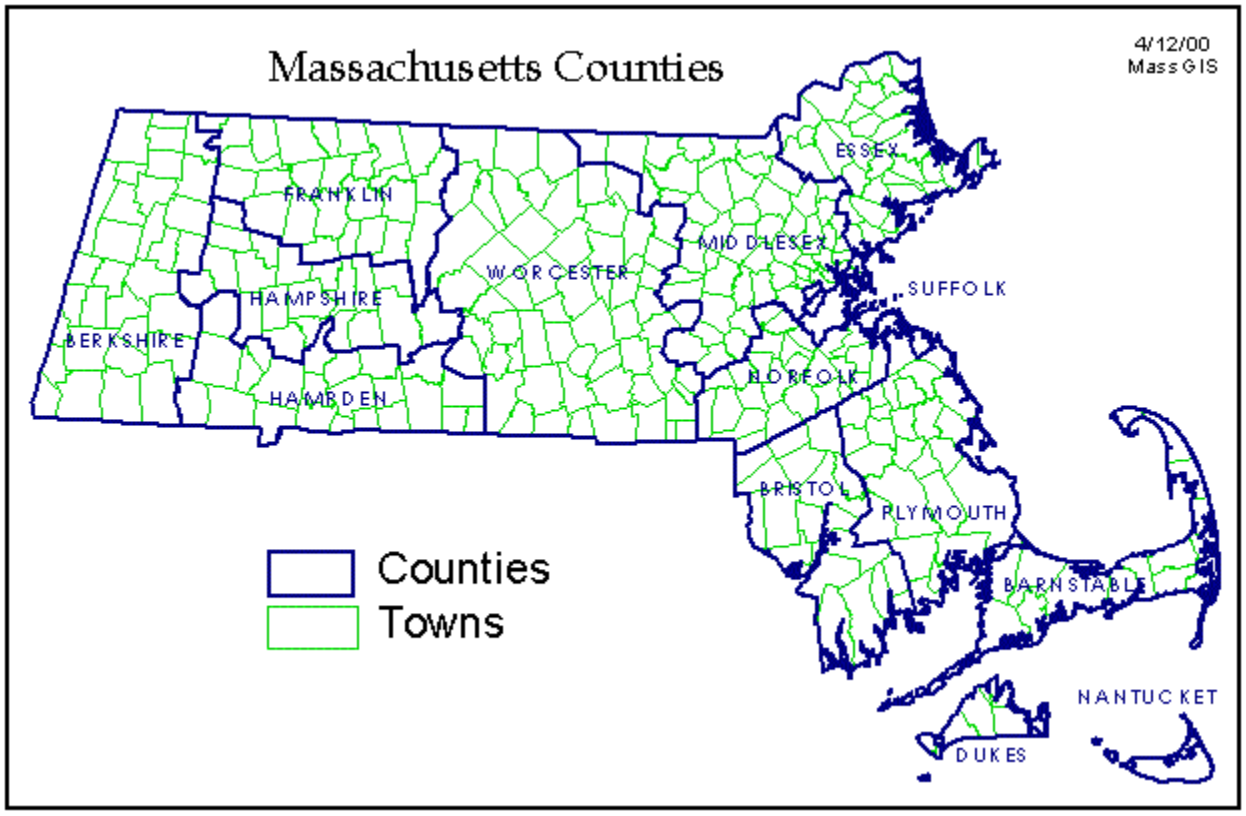
Table 1: List of Towns and Cities in the Actual Central Massachusetts

Ashburnham	Framingham	Milford	Southborough
Ashby	Gardner	Millbury	Southbridge
Ashland	Grafton	Millville	Spencer
Athol	Groton	Natick	Sterling
Auburn	Hardwick	New Braintree	Stow
Ayer	Harvard	Northborough	Sturbridge
Barre	Holden	Northbridge	Sutton
Berlin	Holliston	North Brookfield	Templeton
Blackstone	Hopedale	Oakham	Townsend
Bolton	Hopkinton	Oxford	Upton
Boxborough	Hubbardston	Paxton	Uxbridge
Bolyston	Hudson	Pepperell	Warren
Brookfield	Lancaster	Petersham	Webster

Charlton	Leicester	Phillipston	West Brookfield
Clinton	Leominster	Princeton	Westborough
Douglas	Littleton	Royalston	West Boylston
Dudley	Lunenburg	Rutland	Westminster
Dunstable	Marlborough	Shirley	Winchendon
East Brookfield	Medway	Shrewsbury	Worcester
Fitchburg	Mendon		

This is a list of all the cities and towns that report to the Central Massachusetts Chamber of Commerce (Department of Business and Technology, 2003).

Map 2: Worcester County



As shown in the Massachusetts GIS map.

www.state.ma.us/mgis/ix_cnty.gif

Table 2: List of Towns and Cities in Worcester County

Ashburnham	Gardner	New Braintree	Spencer
Athol	Grafton	Northborough	Sterling
Auburn	Hardwick	Northbridge	Sturbridge
Barre	Harvard	North Brookfield	Sutton
Berlin	Holden	Oakham	Templeton
Blackstone	Hopedale	Oxford	Upton
Bolton	Hubbardston	Paxton	Uxbridge
Bolyston	Lancaster	Petersham	Warren
Brookfield	Leicester	Phillipston	Webster
Charlton	Leominster	Princeton	West Brookfield
Clinton	Lunenburg	Royalston	Westborough
Douglas	Mendon	Rutland	West Boylston
Dudley	Milford	Shrewsbury	Westminster
East Brookfield	Millbury	Southborough	Winchendon
Fitchburg	Millville	Southbridge	Worcester

As listed in the Massachusetts election county separations.

http://www.state.ma.us/sec/ele/elecct/cctidx.htm#worc

Appendix B: North Shore area

Table 1: List of Towns and Cities in North Shore

Amesbury	Lynn	Revere
Beverly	Lynnfield	Rockport
Boxford	Malden	Rowley
Chelsea	Manchester	Salem
Danvers	Marblehead	Salisbury
Everett	Melrose	Saugus
Georgetown	Merrimac	Swampscott
Gloucester	Middleton	Topsfield
Groveland	Nahant	Wakefield
Hamilton	Newbury	Wenham
Haverhill	Newburyport	West Newbury
Ipswich	Peabody	Winthrop

As listed in: www.boston.com/jobs/northshore/

Appendix C: Biomedical Companies in Worcester County

Company Name	Address	Town/City, State, Zip Code	Phone Number
ABBOTT Bioresearch Center, Inc.	100 Research Drive	Worcester, MA 01606	508-849-2500
Abco Welding & Industrial Supply, Inc.	31 Sword St	Auburn, MA 01501	508-791-9293
ACMI Corporation	136 Turnpike Road	Southborough, MA 01772	508-804-2600
Advanced Cell Technology Inc	One Innovation Drive	Worcester, MA 01605	508-756-1212
Aearo Co.	90 Mechanic Street	Southbridge, MA 01550	508-764-5500
Albright Technologies Inc	25 Litchfield St	Leominster, MA 01453	978-466-5870
Alpha Analytical Labs	8 Walkup Drive	Westborough, MA 01581	508-898-9220
Alpha-Beta Technology Inc (ABTI)	One Innovation Drive	Worcester, MA 01605	508-798-6900
Analox Instruments Usa Inc	104 Sunset Ln	Lunenburg, MA 01462	978-582-9368
Antigen Express Inc	100 Barber Avenue	Worcester, MA 01606	508-852-8783
AO SOLA	14 Mechanic Street	Southbridge, MA, 01550	508-764-5000
Araios Inc.	One Innovation Drive	Worcester, MA 01605	617-413-3020
Arrhythmia Research Technology Inc.	25 Sawyer Passway	Fitchburg, MA 01420	978-345-5000
Athena Diagnostics, Inc	377 Plantation Street	Worcester, MA 01605	508-756-2886
Ats Laboratories Inc			
Attogen Inc.	100 Barber Ave	Worcester, MA 01606	
Auralgesic Company, Inc.	16 Johnson Way	Rutland, MA 01543	508-886-6749
Avecia Biotechnology, Inc.	125 Fortune Ave	Milford, MA 01757	508-532-2500
Averica Discovery Service Inc.	One Innovation Drive, Biotech III	Worcester, MA 01605	508-757-4600
Averion International Corp	225 Turnpike Road	Southborough, MA 01772	508-597-6000
Bioactives LLC	1 Dix Street	Worcester, MA 01609	617-489-0424
BioDynamics, Inc.	29 Prospect Street	West Boylston, MA 01583	508-835-6258
Biohybrid Technologies	910 Boston Turnpike Road	Shrewsbury, MA 01545	508-842-4460
Biomeasure, Incorporated	27 Maple Street	Milford, MA 01757	508-478-0144
Biomedical Polymers Inc	42 Linus Allian Ave	Gardner, MA 01440	978-632-2555
Biomedical Research Models, Inc	10 New Bond Street	Worcester, MA 01606	508-852-0606
BioPal, Inc.	80 Webster Street	Worcester, MA 01603	508-770-1190
Biopartners Inc	10 Andy Rd	Worcester, MA 01602	508-755-4645
BioReliance Biotech Inc.	381 Plantation Street	Worcester, MA 01605	508-791-8000
Biosource, Inc.	1200 Millbury Street Suite 7F	Worcester, MA 01607	508-363-2367
BioValve Technologies Inc.	One Innovation Drive	Worcester, MA 01606	508-421-9500
BioVest International, Inc.	377 Plantation St, Biotech 4	Worcester, MA 01605	508-793-0001
Blue Sky Biotech, Inc.	60 Prescott Street	Worcester, MA 01605	508-831-1295
Boston Medical Products, Inc.	117 Flanders Road	Westborough, MA 01581	508-898-9300

Brendan Bioscience, LLC	3A Business Way	Hopedale, MA 01747	508-473-8899
Brochu Bio-Lab Services	400 Thompson Road	Webster, MA 01570	508-943-9750
BURLE Electro-Optics, Inc.	PO Box 1159, Sturbridge Bus. Park	Sturbridge, MA 01566	508-347-4000
Cellthera Inc.	431 High Street	Southbridge, MA 01550	508-765-0276
Central Coating Co, Inc.	165 Shrewsbury St	West Boylston, MA 01583	508-835-6225
CereMedix, Inc.	One Innovation Drive	Worcester, MA 01605	508-459-5924
Charles River	57 Union St	Worcester, MA 01608	508-890-0100
Coley Pharmaceutical Group, Inc.	93 Worcester St.	Wellesley, MA 02481	781-431-9000
Consistent Cardiogram Corp	25 Winthrop Street	Worcester, MA 01604	
Cool Laser Optics	57 E Main Street	Westborough, MA 01581	508-870-0066
Crescent Innovations Inc			
Cryogenic Institute of New England	90 Ellsworth St	Worcester, MA 01610	508-459-7447
Cyberkinetics Neurotechnology	100 Foxborough Blvd.	Foxborough, MA 02035	508-549-9981
Databased Inc			
Dosco Sheet Metal & mfg	6 Grafton St	Millbury, MA 01527	508-865-9998
Doss Plastics, Inc.	94 Ashland Ave.	Southbridge, MA 01550	508-764-3211
Eac			
East Acres Farms Inc.	236 Blackmer Rd.	Southbridge, MA 01550	508-765-0535
Eastwest Pharmaceutical International	33 Hemingway St	Shrewsbury, MA 01545	508-791-8544
ECI Biotech, Inc	85 Prescott Street	Worcester, MA 01605	508-752-2209
Eden Research plc			
Emuge Corporation	1800 Century Dr	West Boylston, MA 01583	508-595-3619
Entegrion Inc.			
EpigenDX	15 Harris Ln	Ashland, MA 01721	508-881-6810
Filtrona Extrusion Inc	170 Bartlett St	Northborough, MA 01532	508-393-2553
Fisher Scientific	8 Forge Pkwy	Franklin, MA 02038	508-553-5000
Funnel Insruments LLC	79 Hecla St	Uxbridge, MA 01569	508-278-0800
Gene-IT	25 Winthrop Street	Worcester, MA 01604	508-754-7300
Genetex Optics Inc	183 West Main	Dudly, MA 01571	508-943-3860
Genzyme Genetics	3400 Computer Drive	Westborough, MA 01581	508-898-9001
GLSynthesis, Inc	One Innovation Drive	Worcester, MA 01605	508-845-9484
GlucaDel Consulting			
GlycoSolutions, Corp.	25 Winthrop Street	Worcester, MA 01604	508-756-6418
Gyrus Acmi	136 Turnpike Road	Southborough, MA 01772	508-8042600
Hematech	377 Plantation St.	Worcester, MA 01605	508-792-0682
Hightech Precision Moulders LLC	30 Patriots Circle	Leominster, MA 01453	978-534-5000
Hypnion Inc	381 Plantation Street	Worcester, MA 01605	508-438-2800
Hypromatrix, Inc.	100 Barber Ave	Worcester, MA 01606	508-856-7900
Imaging Diagnostics, Inc.	98 Pratts Junction Rd	Sterling, MA 01564	978-422-8601

Imaging Diagnostics, Inc.	99 Pratts Junction Rd	Sterling, MA 01565	978-422-8602
Indigene Pharmaceuticals, Inc.	115 Flanders Rd.	Westborough, MA 01581	508-389-1701
Infonetics Corp.	2 Flint Meadow Ln.	Shrewsbury, MA 01345	508-845-9824
Informatics & Computing Resources Center			
Infussafe	13 Massachusetts Ave	Harvard, MA 01451	978-805-3183
Innovend	30 Patriots Cir	Leominster, MA 01453	978-534-5000
Insight Neuroimaging Systems, LLC	111 Canterbury St	Worcester, MA 01610	508-799-6464
Integrated Pharmaceuticals Inc	310 Authority Dr	Fitchburg, MA 01420	978-696-0020
JR Medical Technology	123 Briar Wood Ave	Southbridge, MA 01550	508-764-2121
Kinefac Corp	156 Goddard Memorial Drive	Worcester, MA 01603	508-754-6891
Laser Therapeutics Inc	101 Waterside Dr	Centerville, MA 02632	508-790-9300
Latham Laboratories Inc	Worcester Biotechnology Park	Worcester, MA 01605	
Lex Company	178 Lincoln Street	Worcester, MA 01605	
LINOS Photonics, Inc.	459 Fortune Blvd.	Milford, MA 01757	508-478-6200
Liporx Pharmaceuticals Inc	One Innovation Drive	Worcester, MA 01605	
Luxtec Corporation	326 Clark St.	Worcester, MA 01606	508-856-9454
Mar-lee Companies	190 Authority Dr	Fitchburg, MA 01420	978-343-9600
Mar-lee Companies, Inc	180 Authority Dr	Fitchburg, MA 01420	978-348-1291
Mass Biotechnology Research Park	One Innovation Drive	Worcester, MA 01605	508-755-2230
Mass Histology Service	31 Huron Ave	Worcester, MA 01605	508-853-9363
Massachusetts Biomedical Initiatives	60 Prescott Street	Worcester, MA 01605	508-797-4200
Mass Micro Laboratories, Inc.	25 Winthrop Street	Worcester, MA 01604	508-752-0858
Medcon Biolab Technologies	50 Brigham Hill Rd	Grafton, MA 01519	508-839-4203
Medical Equipment Specialists Inc	14 Lake Ave	Worcester, MA 01604	508-757-3390
Microbiotix Inc	One Innovation Drive	Worcester, MA 01605	508-757-2800
Micron Products Inc	25 Sawyer Passway	Fitchburg, MA 01420	978-345-5000
Miniature Tool & Die, Inc.	15 Trolley Crossing Rd	Charlton, MA 01507	508-248-0111
Mossman Associates Inc	9 Village Cir	Milford, MA 01757	508-488-6169
Mtm Laboratories Inc	134 Flanders Rd Ste 325	Westborough, MA 01581	508-366-8334
Netoptix Corp	PO Box 550, Sturbridge Buisness Park	Sturbridge, MA 01566	508-347-9191
New England Peptide Inc	65 Zub Lane	Gardner, MA 01440	888-343-5974
New World Laboratories	25 Winthrop Street	Worcester, MA 01604	
News Technical Gases	31 Sword Street	Auburn, MA 01501	508-791-9293
NOVAGENESIS	One Innovation Drive, Biotech III	Worcester, MA 01605	508-797-6682
NP Medical, Inc.	101 Union Street	Clinton, MA 01510	978-365-2500
NuGenesis Technologies Corporation	1900 West Park Drive	Westborough, MA 01581	508-616-9876
Oliver M Dean Inc	125 Brooks St	Worcester, MA 01606	508-856-9100
Omega PharmServices, Inc.	113 Cedar St. Suite S-6	Milford, MA 01757	508-482-9330

OPCO Laboratory Inc	704 River Street	Fitchburg, MA 01420	978-345-2522
OPTIM, Inc.	64 Technology Park Road	Sturbridge, MA 01566	800-225-7486
Optimum Technologies, Inc.	68 West Street	Southbridge, MA 01550	508-765-8100
Pgm Plastics Inc	774 Crawford St	Fitchburg, MA 01420	978-342-6767
Pharm Development Consulting			
Physical Research	451 Worcester Road; Route 20	Charlton, MA 01507	508-865-9103
Phytera Inc	377 Plantation Street	Worcester, MA 01605	508 792-6800
Plant Pharmaceuticals Inc	One Innovation Drive	Worcester, MA 01605	
PolyCarbon Industries, Inc.	435 Lancaster Street	Leominster, MA 01453	978-772-2111
PolyOrg, Inc.	10 Powers Street	Leominster, MA 01453	978-466-7978
Precision Optics Corporation	22 E Broadway	Gardner, MA 01440	978-630-1800
ProFoldin			
Pyrosequencing Inc	2200 West Park Drive, Suite 320	Westborough, MA 01581	508-389-9911
Q-One Biotechnologies, Ltd.	381 Plantation Street	Worcester, MA 01604	508-791-8000
Radius Product Development	200 Union St	Clinton, MA 01510	978-368-3200
REM Inc			
RenalPlant Corporation	5 Leonard Drive	Southborough, MA 01722	508-624-0150
RES-TECH Corporation	22 Marshall Street	Clinton, MA 01510	978-368-0146
Rocheleau Tool & Die Co Inc	117 Industrial Rd	Fitchburg, MA 01420	978-345-1723
RXi Pharmaceuticals Corporation	1 Innovation Drive	Worcester, MA 01605	508-767-3861
Saint-Gobain Abrasives Inc.	1 New Bond St.	Worcester, MA 01606	508-795-5000
Schott Fiber Optics, Inc	122 Charlton Street	Southbridge, MA 01550	800-343-6120
Seatech Bioproducts Corp	159 Memorial Drive; Unit C	Shrewsbury, MA 01545	508-842-9292
Select Engineering Inc	260 Lunenburg St	Fitchburg, MA 01420	978-345-4400
SelectX Pharmaceuticals, Inc.	One Innovation Drive, Biotech III	Worcester, MA 01605	508-798-0216
SeraCare Diagnostics	25 Birch Street	Milford, MA 01757	508-478-5510
Shire Biologics Inc	30 Bearfoot Road	Northborough, MA 01532	508-351-9944
SquiCor Labs Inc.	80 Optical Drive	Southbridge, MA 01550	360-450-4140
Steelcraft	115 W. Main Street	Millbury, MA 01463	508-865-4445
Steris-Isomedix Services	435 Whitney Street	Northborough, MA 01532	508-393-9323
Stethographics Inc	21 Wayside Rd	Westborough, MA 01581	508-320-2841
Targeted Cell Therapies	60 Prescott Street	Worcester, MA 01605	508-517-8400
Techman International Corp	16B Sturbridge Road	Charlton, MA 01507	508-248-2900
Technical Innovation Center, Inc.	100 Barber Avenue	Worcester, MA 01606	508-799-6700
T M Electronics	45 Main Street	Boylston, MA 01505	508-856-0500
TranXenoGen, Inc.	800 Boston Turnpike	Shrewsbury, MA 01545	508-936-4200
Valeritas, LLC	800 Boston Turnpike (Route 9)	Shrewsbury, MA 01545	508-845-1177
Valmed, Inc.	221 Spring Street	Shrewsbury, MA 01545	508-845-3438
Vascular Sciences	44 Edward Drive	North Grafton, MA 01536	508-887-9486

Verax Biomedical Incorporated	377 Plantation St, Biotech 4	Worcester, MA 01605	508-755-7029
Viking Systems	134 Flanders Rd	Westborough, MA 01581	508-366-8882
Vista Medical Technologies	134 Flanders Road	Westborough, MA 01581	508-366-3668
VivaScan Corp.	560 Prospect St	West Boylston, MA 01583	508-852-1600
Water Corporation	34 Maple Street	Milford, MA 01757	508-478-2000
Welgen, Inc.	25 Winthrop Street	Worcester, MA 01604	888-493-5436
WesaGen Inc			
Zoaan Diagnostics, Inc.	159 Memorial Drive; Unit C	Shrewsbury, MA 01545	508-842-9020